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THE MILKY WAY, AND THE DISTRIBUTION OF STARS WITH PECULIAR SPECTRA

BY T. E. ESPIN

THE late Mrs. Fleming's researches, which have revealed so many stars with peculiar spectra, have been lately published in *Harvard Annals*, Vol. LVI., No. 6. The places are given for 1900, also the galactic longitude and latitude. It becomes therefore a simple matter to collect these objects into tables, and so show their relation to the Milky Way.

In the following tables the letters at the head of each column refer to the classes of objects :—

T New Stars.
P Gaseous Nebulæ.
O Type V.
H Hydrogen lines bright.
AV Algol variables.
SV Short period variables.
LV β Lyræ variables.
Md Long period variables with bright hydrogen lines.
N Type IV.
R Type VI.

Under *P, O, H,* objects in the Magellanic clouds are excluded, and under *Md* only the objects, whose spectra have been photographed, are included. In the case of *N*, the spectra are so faint that a large number have not been found on the plates. It has been thought well however to take the mean of the number actually photographed, and of the total number, excluding only those that have been proved not to be Type IV.

In addition the stars of Types *A, B, F, G, K, M,* have been taken from *Harvard Annals*, Vol. LVI., No 1. In Table I. the percentages are arranged in order, and the various bodies classified accordingly. Division I. shows the greatest concentration, while Division V. passes from slight concentration to actual avoidance of the Milky Way.

TABLE I

PERCENTAGES ACCORDING TO GALACTIC LATITUDE

Galactic Latitude	I		II			III			IV			V				
	O	*T*	*H*	*P*	*N*	*SV*	*AV*	*LV*	*B*	*A*	*R*	*G*	*Md*	*M*	*K*	*F*
0° to 10°	97·7	78·6	61·4	59·7	54·6	53·5	49·2	46·1	42·8	34·7	29·8	21·8	21·3	18·4	17·6	15·7
10° 20°	2·3	7·1	22·9	23·4	24·7	21·4	22·4	23·1	35·6	23·9	21·3	16·9	22.1	20·3	17·4	17·2
20° 30°		10·7	7·3	3·2	9·5	4·8	11·9	7·7	15·4	19·9	16·4	21·0	16·9	17·9	20·6	21·4
30° 60°		3·6	8·4	13·7	8·9	16·1	15·0	15·4	5·2	18·7	27·7	33·0	32·2	37·1	38·2	38·8
60° 90°					2·3	4·2	1·5	7·7	1·0	2·8	4·8	7·3	7·5	6.3	6·2	6.9

Class *O* quite clearly marks out the galactic equator, the mean deviation being 1° 55′. But this class is not evenly distributed. Of 84 stars no less than 60 are found south of the galactic equator, and only 24 north. Are the other classes equally affected by this peculiarity? In Table II. the percentages for all classes are arranged in order of N and S Galactic latitude :—

TABLE II

Galactic Latitude	I				II				III							
	H	*O*	*P*	*B*	*R*	*T*	*LV*	*SV*	*K*	*F*	*M*	*Md*	*G*	*N*	*A*	*AV*
+	28·8	29 1	31·8	33·7	36·0	37·0	38·5	38·6	42·1	42·2	43·2	44·4	48·3	48.5	49·1	50·8
−	71·2	70·9	68·2	66·3	63·4	63·0	61·5	61·4	57·9	57·8	56·8	55·6	51·7	51·5	50·9	49·2
Difference	-42·4	-41·8	-36·4	-32·6	-26·8	-26·0	-23·0	-22·8	-15·8	-15·6	-13·6	-11·2	-3·4	-3·0	-1·8	+1·6

An inspection of these two tables leads to some interesting speculations.

(*a*) Table II. informs us that all classes have a minus sign with the exception of the Algol variables.

(*b*) The rearrangement in order in Table II. when compared with Table I. should be noticed. Class *B* now falls into Division I. while the temporary stars join the β Lyræ and short period variables. Algol variables come next to Class *A*, as we should expect them to do from the predominence of the *A* Type of spectrum among these bodies, and Division III. in Table II. is identical with IV. and V. in Table I. but *in the reverse order*, leaving out of our consideration *N* and *R*.

(*c*) Obviously comparing Tables I. and II. together, it seems to be a fact that the greater the condensation towards the galactic equator, the higher the percentage of stars with minus sign. This is exactly what should occur if the sun has north galactic latitude. It is quite clear that the more a class of stars is condensed on the equator, the larger the number of stars that will be apparently pushed over the middle line. In Table II., Division III., we have the stars which are more uniformly distributed than those of Division I. They are for the most part believed to be nearer the sun. If so, we may hazard a further speculation, that the displacement varies here according to proximity, and that Class *K* is nearer to us than Class *A*.

(*d*) Another possibility arises from an inspection of Division IV. and V. in Table I. and Division III. in Table II. and that is that we may have to rearrange our sequence of spectral types. Professor Pickering long since called attention to the fact that Class *F*, while having a spectrum midway between *A* and *G*, does not in distribution fall midway between them. "The result," he says, "was wholly unexpected" (*Harvard Annals*, Vol. LVI., No. 1, p. 17). Table I. suggests a further step. Type *M* appears to be the centre, and the true sequence is probably *A*, *G*, *M*, *K*, *F*, and Table II. confirms this by showing that the stars believed to be most distant, viz., Class *A*, are but slightly displaced, while

those nearest, *F* and *K*, have the maximum displacement in this Division.

(*e*) If we consider Division III. in Table I. we find here the variables of short period, of the Algol type, and of the β Lyræ type. Let us under each heading count the number which fall to each class of spectra — doubtful cases being rejected. We have: —

TABLE III

Spectrum	Algol	*SV*	*LV*
A	76	11	8
B	14	0	2
G	2	41	1
M	0	6	0
K	0	14	0
F	7	31	2

Now we should expect a concentration towards the equator equal to the predominating type of spectrum. In Table II. the Algol stars follow the law that governs *A*, but the short period and β Lyræ variables maintain their position very much as in Table I. and are joined by the temporary stars. May we not legitimately draw the inference that in all these types the conditions which give rise to variation show greater activity in the neighborhood of the galactic equator?

(*f*) The position of Class *N* in the two tables is significant. Table I. shows a strong condensation towards the galactic equator, Table II. informs us that their displacement ranks them with Class *A*. Class *R* which has a more uniform distribution in Table I. shows in Table II. a large displacement to the south. But it must be remembered that our knowledge of both classes is very imperfect. In Table IV. we may find the percentages of all the classes in longitude for every 90°.

TABLE IV

Longitude		*B*	*A*	*G*	*M*	*F*	*K*	*R*	*H*	*O*	*AV*	*P*	*SV*	*T*	*Md*	*N*	*LV*
0° to	90°	9·0	10·2	11·3	12·1	12·5	13·9	14·7	15·8	26·7	29·1	29·4	29·8	30·8	31·8	36·9	69·2
90°	180°	27·8	24·8	26 5	20·4	26. 5	21·9	14·7	17·2	4·7	28·4	20·6	26·6	15·4	19·1	27·4	0
180°	270°	30·6	30 8	29·3	34.3	30 3	34·8	23·0	35·3	32·6	13·4	15·9	15·2	7·6	16·9	18·3	7·7
270°	360	32·6	34·2	32·9	33.2	30·7	33·2	47·6	31·7	36·0	29·1	34·1	28·4	46·2	32·2	17·4	23·1

We may note from this Table, and from a more minute analysis :—

(*a*) The relations found in Tables I. and II. between *A*, *G*, *M*, *F*, *K*, are confirmed.

(*b*) The relation of *R* and *N* is such that the maximum of one corresponds with the minimum of the other.

(*c*) Class *O* has maxima in Argo and Cygnus near the apparent ends of the bifurcation of the Milky Way.

(*d*) Class *P* comes to a maximum nearly midway between the maxima of *O*.

(*e*) Class *H* reaches its maximum between Canis Major and Argo.

(*f*) In Class *T* the maximum corresponds with that of *P*, and the curve of distribution is similar.

(*g*) Classes *AV*, *SV*, *Md*, have a similar curve of distribution, and also seem closely related to *T*.

(*h*) Although *SV* contains stars of various classes, the fact that they do not conform to the distribution of these classes is again brought out.

In Mrs. Fleming's memoir the objects *T*, which have shown a nebular spectrum, are included in Class *P*. In the Tables here given *T* has been separated from *P*, so that the similar distribution in longitude is all the more striking.

The question now arises how far these conclusions are facts and how far they are accidents. We must remember that with increased optical means, new discoveries will be made, but we are at any rate safe in saying that for the brighter objects our conclusion, hold good. It remains to enquire whether any new

solution of the formation of the Galaxy may be derived from them. A chart was therefore made, showing the Milky Way, the elements being adopted from Gould.

The chief classes in *Harvard Annals*, Vol. LVI., No. 6, were laid down on the chart, when the most astonishing fact was at once apparent, viz., that in the summer Galaxy, the stream that is *N* of the galactic equator is practically ignored by all classes. This fact puzzled me very much indeed. Obviously too, the stars of Type *V* followed neither one nor the other, but kept steadily near the central line. The objects in Class *P* showed a preference for the southern stream. Class *H* and Class *T* gave no certain indication save that *T* came to a maximum in south galactic latitude. The only class not included in *Harvard Annals*, Vol. LVI., No. 6, which shows any affinity for the Galaxy is Class *B*, consisting of helium stars. A catalogue of these as far as they are known is given in *Harvard Annals*, Vol. LVI., No. 2. A second chart was therefore prepared, showing in galactic co-ordinates the Classes *B*, *O*, *P*, *H*, *T*, and *SV*. The results were very striking. The elements of the bifurcation as given by Gould were roughly laid down, and continued as well through the winter Galaxy. The first and most evident fact was that the η Carinæ region was the great centre from which all galactic objects radiate. The next was that the stars of Class *B* show well defined groups, which tend to arrange themselves, near the *opposite* stream to that associated with *P*. The stream which had no connection with any of the objects in *Harvard Annals*, Vol. LVI., No. 6, was now found to be closely associated with the helium stars. The intersection of the two was evidently in η Carinæ. The opposite intersection is not well marked, and may be at λ 44°, or λ 75°. The addition of Class *SV* seem by their grouping to point to the latter. Further, the point midway between, viz., $\lambda = 345°$, appears to be closely associated with a grouping of *P*, and *T* and *SV*, and the disappearance of *B*, and possibly *O*. The chart lends no colour to the theory of two independent rings, but to two rings which though intersecting each other are yet closely related to each other and to the central circle of the

Galaxy. On this hypothesis it remains to enquire whether the general features of the Galaxy can be so explained. Let us try briefly and see if this can be done satisfactorily.

In Fig. 1, let P be the centre of the circle in which the planetary nebulæ abound, and B the centre of the circle characterized by the presence of helium stars, A A^1 the intersection of the two circles. If we describe a large circle from centre S, then A and A^1 will be 180° apart, but if from any point on a line SP, A and A^1 will be less than 180°, while if from any point in

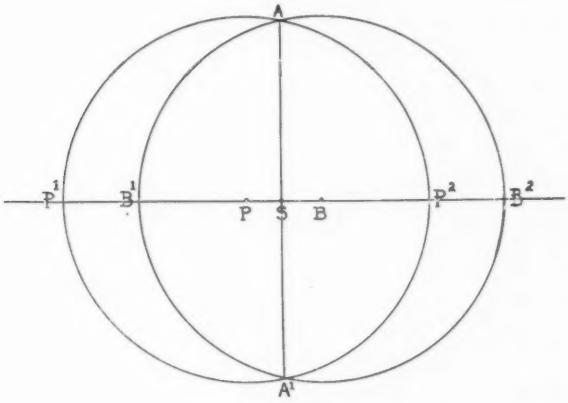


FIG. 1

the direction of SB, they will be more than 180°. Now if we suppose that the group of fifth type stars round P Cygni be the intersection, the distance from A^1 (η Carinæ) to A (P Cygni) is 148°·5, clearly in this case the sun's place must be in the direction SP, in such a position that the arc A to A^1 (the galactic equator) shall equal 148°·5. At the same time it must be observed that the fifth type stars show a tendency to group at λ 75° ± which would then place the position of the sun on the line that joins A and A^1. Evidently any position in the direction SB, is quite out of harmony with the observed facts. Again it is clear that if we consider the circle of B, whether the

sun's position be at P or S the stars at B^2 will be nearer than those at B^1, and therefore much brighter. Now the helium stars in Orion and those in Scorpio nearly occupy the positions of B^1 and B^2, and, as we should expect, the helium stars in Orion are not only much brighter but more numerous. In like manner in the case P^1 and P^2, if we consider the sun's position to be S, the Galaxy at P^2 will be brighter than at P^1, and this will be true of any point that is selected between S and P. We shall then have a brilliant summer Galaxy from the nearness of P^2, and a fainter winter Galaxy from the distance of P^1, compensated by the brilliant Helium stars of B^2, and this is just what we find. Let us next consider what will be the effect of the sun's position with regard to the plane of the Galaxy. In Fig. 2, the line P^1B^2 is the section of the Galaxy. Obviously if the sun is at S^1 the various points B^1, P^1, P^2, B^2 will appear projected one upon another, but if the sun is at S, a very different result will be obtained. While SA is the projection of the galactic equator, the stars at B^1 being projected in the direction $S\,B^1$, will have south galactic latitude while the stars at B^2 will in the same manner

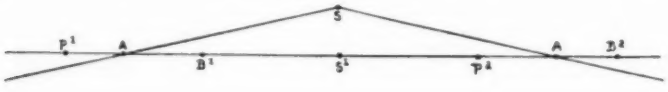


FIG. 2

have north galactic latitude. In other words the helium stars in Orion will be to the south of the Galaxy while those in Scorpio are north, which is actually the case. In the same way the most brilliant stream of the summer Galaxy P^2 will be projected south of the equator. We know that the circle B abounds in vast nebulous masses, and it is quite thinkable if these lie in sufficient breadth and density between $A\,B^1$ and $A\,B^2$ that they will to a great extent absorb P^2, and so dim down and narrow the winter Galaxy, the most brilliant part of which P^1 is at its greatast distance also. In the same way in the summer Galaxy, it may in a measure by absorbing B^2 cause the apparent bifurcation.

This hypothesis, though not without its difficulties, combines in one the galactic bodies and the vast nebulous masses such as those in Orion and Scorpio, and at the same time gives at any rate a tentative explanation of the brightness and faintness of the Milky Way in the summer and winter skies; it helps to explain the brilliancy of the stars in Orion and in that part of the sky where there are helium stars.

The general arrangement of the families in orders of spectra is well shown on the chart, and valuable hints are given by its inspection as to where we may most successfully look for undetected members. The stars of the fifth type for instance, if more should be discovered, will be most likely found as we approach λ 255° and λ 75°. The temporary stars lie near λ 325°, while the opposite pole near λ 145° has lately been marked by the new star in Gemini. The home of the objects of Class *P* centres at λ 335°, short period variables at λ 350° and λ 75°, and so forth.

This paper would be incomplete without a word of deep appreciation of the work of Mrs. Fleming. Her painstaking researches have alone made it possible. It is a great loss to science that she was not spared long enough to do thoroughly what here has been but inadequately done.

Tow Law,
Co. Durham, England
January, 6th, 1913.

"SAVED BY A SHADOW"

By William F. Rigge

IN an Omaha criminal court a short time ago, the fate of an accused man hung upon a shadow, that is to say, it depended upon the accuracy with which the time of exposure of a certain photograph could be deduced from the position of a shadow. The circumstances were as follows:

On Sunday, May 22, 1910, a suit-case containing dynamite was found on D's porch at 2.50 o'clock in the afternoon. E was arrested and accused of having placed it there with criminal intent. The state produced only two witnesses, girls 17 and 11 years of age, who said that while walking in the neighborhood shortly before three o'clock they had seen a man answering E's description carrying such a suit-case. The attorney for the defense, John O. Yeiser, found that the girls had just come from a church a mile away. They had attended services there, and had posed for their photographs twice in front of the building. A prominent shadow in one of the pictures gave the attorney the idea of consulting an astronomer in the hope of finding from the position of the shadow the time at which the plate had been exposed. Should this prove to be after 2.50 o'clock, the testimony of the witnesses would be invalid.

His friends directed him to me. With the help of a surveyor, we measured the distances the shadow had fallen down, eastward and northward. The data obtained furnished four different methods of computation. The principle is a very simple one to those that understand the elements of trigonometry and astronomy. "It is briefly this" and here I am quoting from the *Scientific American*, of February 4, 1911:

"It is briefly this, that in measuring the distance that a shadow is cast down, north or south, and east or west, we can

find the sun's place in the sky at the moment, and thence deduce the time of the day and the day of the year. For this purpose we make use of the astronomical triangle whose vertices are the zenith, the pole, and the sun. The side extending from the zenith to the pole is the complement of the latitude of the place. The side from the pole to the sun is the complement of the sun's declination. The third side, from the sun to the zenith, is the sun's zenith distance, the complement of its altitude. The angle at the zenith is the sun's azimuth counted from the north. The angle at the pole is the sun's hour angle, the local apparent solar time. The angle at the sun is called the parallactic angle.

"Of these six parts, three sides and three angles, three must be given in order to enable us to compute the rest. In the present instance, the sun's azimuth was known from the ratio of the distances that the shadow was cast eastward and northward. The sun's altitude also was known from the ratio of the vertical and horizontal distances. The latitude and longitude were obtained from the city map with reference to our observatory. And finally the sun's declination was known, because the day was given and the hour was about 3 p.m.

"There were thus four out of the six parts of the triangle given, one part more than was needed. As the angles at the pole and at the sun were the only unknowns, each of the four known parts was in turn taken as the third unknown. This furnished four methods of solving the problem, in which, along with the time and the parallactic angle, the sun's altitude, azimuth, and declination, and the latitude of the place were successively taken as unknowns. The results were :

3 o'clock 21 minutes 12 seconds.
3 o'clock 21 minutes 31 seconds.
3 o'clock 21 minutes 29 seconds.
3 o'clock 21 minutes 33 seconds.

The mean of which was 3 o'clock 21 minutes 26 seconds, and the residuals, or differences from the mean, 14, 5, 3, 7 seconds, the extremes being 21 seconds apart.

"The close agreement, of the four methods showed that no

appreciable error had been made in any of them. In the first method the azimuth of the sun had been obtained by assuming the curb line of the street to be correctly in the meridian. The second method made no use of the azimuth at all. The third method used no other data than the latitude and longitude of the place and the measures made upon the building, and found from them the time of the day as well as the day of the year. The error in the computed declination of the sun was about one-fourth of its daily variation at the time, so that there could be no doubt whatever of the day. The date, as far as the shadow was concerned, might also have been July 22nd as well as May 22nd, because on both of these days the sun's declination is the same. But besides being altogether out of the question, the later date was negatived by the immature condition of the foliage shown in the photograph.

"In the fourth method the latitude, which had been taken as unknown, differed only 4⅔ miles from the truth. If the time had been given, the longitude would have been found within about the same range.

"The data used in the problem were that the shadow had fallen 14·22 feet down, 13·10 feet eastward, and 3·43 feet northward. The horizontal distance was found to be 13·52 by measurement and 13·54 by computation. An error of one-tenth of a foot in the shortest horizontal side would have changed the time 1 minute 54 seconds. The same error in the altitude would have caused a difference of 1 minute 15 seconds. The omission of the correction for refraction would have produced a difference of 2 or 3 seconds. The latitude was 41 deg. 16m. 42s. N. and the longitude 6h. 25m. 48s. W. The sun was 3 minutes 33 seconds fast, and the time used central time."

In order not to claim too great an accuracy for the results I thought I would leave a reasonable margin of uncertainty by maintaining the time 3·21½ to be within a minute of the truth.

But even the close agreement of the four methods would probably never have induced me to bear testimony in court, had I not had the experience of a similar problem about seven years

before, in which I found the time of the day, the day of the year, and even the year itself, from a shadow in a photograph of our Observatory. Further particulars in regard to both pictures may be found in the *Scientific American* of September 24, 1904; February 4, 1911, and July 20, 1912.

The scientific testimony split the jury in the first trial. At the second trial the attorney for the prosecution, an expert criminal lawyer, realized that his only hope of success lay in overthrowing, or at last weakening, the astronomical evidence advanced by the defence. He therefore belittled the calculations and positive assurance of scientific men generally, and by his sarcasm and witticisms kept the jury in continuous laughter. The result was a tribute to his skill in handling a jury, an unanimous verdict of "Guilty," which drew a sentence of fifteen years in the penitentiary.

The defence then appealed to the Supreme Court. While its decision was pending, the first anniversary, May 22, 1911, of the taking of the photograph occurred. The day was partly cloudy, and pressing business made it impossible for me to go to the place of the shadow. The next day, however, was bright, and I was free to go. I then had the supreme satisfaction to see with my own eyes that the shadow must have been on the previous day so close to its place on the photograph, that my probable error of a whole minute could not have been an actual one greater than a quarter of that amount.

If the close agreement of my four methods of computation had given me such a degree of certainty that I could declare upon my honor I was not in error by more than a minute, the actual sight of the shadow increased my certainty a thousandfold and made me feel that I could safely defy the world, that anyone differing from me by more than a minute must be decidedly in error, and that I could challenge him and everybody to come and see the shadow at any anniversary. And if a third trial of the same case should ever become necessary, I knew I had an argument in my possession that must convince any jury and must outweigh in their minds all the mathematics in the world.

"Some months later" — to quote from the *Scientific American*, of July 20, 1912, "the Supreme Court decided that the accused had been convicted upon insufficient evidence. In preparing for a third trial, the prosecution called upon G. D. Swezey, Professor of Astronomy at the University of Nebraska, to remeasure the position of the shadow and recompute the time. Professor Swezey, narrating the event at a public meeting of the Nebraska Academy of Science, held in Lincoln, on May 3rd last, said that he studiously refrained from consulting or even referring to any of the former measurements or findings until he had completed his own calculations. The outcome was that he obtained a difference of only twenty-nine seconds, thus falling decidedly within the one minute that the defence had allowed as a probable error. The State then abandoned the prosecution."

A still more convincing proof of the accuracy of the first calculations was to come. I felt all along that the only way to dispel the doubts still lingering in the minds of some people, to whom astronomical and mathematical methods were unintelligible, was to make a public appeal to a fact, which anyone who wished to might verify for himself.

Three days before the second anniversary drew nigh, that is, on Sunday, May 19, 1912, I published a short article in the the *World-Herald*, of Omaha, under the headlines, "Shadow will be there, says Father Rigge. Scientist invites critics to sift the evidence by observation." It reproduced the original photograph with its shadow, and concluded with these words: "Next Wednesday, May 22, will be the second anniversary of the taking of the photograph. Within one minute of twenty-one and a half minutes after three o'clock the shadow will be in exactly the same position it occupied at the time the photograph was taken. It was there last year at that time, and it will be there each anniversary as long as the church stands. Anyone interested in the matter may go to Twenty-eighth and Parker Streets and verify the fact for himself."

When the appointed hour arrived, the Omaha *Daily News* sent its photographer to take the picture of the shadow and com-

pare it with the original. Three exposures were made: The first at 3.20½, a minute before the computed time; the second at 3.21½, exactly on time; and the third at 3 22½, a minute after the computed moment. How closely the middle picture reproduced the exact position of the shadow as it appears on the original photograph of two years before, can be seen at any time by actual comparison. In both the lower left hand corner of the shadow is exactly in the middle of the same weatherboard. It is somewhat below this spot in the picture taken a minute before, and as much above it in the one taken a minute later. The computed time was therefore certainly correct to the minute, and probably so even within a few seconds.

NOTE.—The objection may occur to some astronomers that, as the day and the tropical year are incommensurable, the sun can never on any anniversary reach the same declination at the same time of the day, and that consequently a shadow can never again fall on the same spot. In theory the objection is well taken, but in practice it is of no consequence.

If we plot upon the wall of the church the path of the shadow, of which there is question in the present instance, we shall find that at the time being it moved at the rate of 1·14 inches or 0·096 feet a minute, and that the paths of the preceding and following days were at a distance of very nearly three-quarters of an inch on either side, the change in the sun's declination in one day being very close to 12 minutes of arc. From this it follows that, because the calendar year was one-fourth of a day shorter than the tropical year, the sun's declination on the first anniversary at the same hour was less by one-fourth of 12 minutes, that is, by 3 minutes of arc, and the path of the shadow was one-fourth of three-quarters of an inch, that is, three sixteenths of an inch, above its former one of the preceding year.

The second anniversary, May 22, 1912, occurred in a leap year. If the year had been an ordinary one, the sun's declination would have been 3 minutes of arc less than in the preceding year and 6 minutes less than it was on May 22, 1910, and the shadow path would have been three-eighths of an inch higher. This was, of course, the fact on May 21, 1912. By the following day, May 22, 1912, the sun's declination had increased 12 minutes. It was, therefore, 6 minutes more than it had been on May 22, 1910, and the shadow path was three-eighths of an inch lower than on that day.

As the two paths of May 21 and 22, 1912, were at the same distance on either side of the original one of May 22, 1910, I might have taken either date, but I judged it best to select the latter and to adhere to the ordinary meaning of the word anniversary in order not to give rise to this very difficulty.

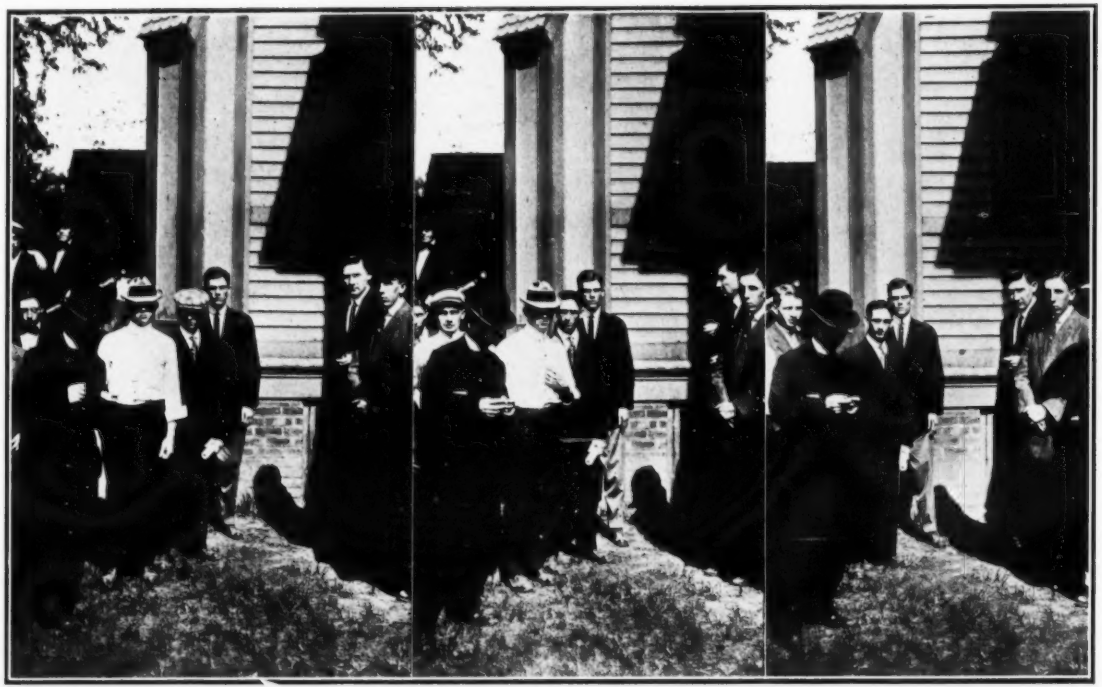
The difference of 6 minutes of arc in the sun's declination on May 22, 1910 and May 22, 1912, displaced the shadow path laterally, as I have said, three-eighths of an inch. This entailed a much smaller longitudinal displacement in hour angle, in which, however, my probable error of a whole minute allowed me a range of over an inch, or three times as much, in either direction. If we take into consideration the additional facts that a shadow is always bordered by a penumbra which makes it difficult to locate it with precision, and that the original photograph is on a scale less than one-fiftieth of the reality, I think that not even an expert astronomer would hesitate to pronounce the two photographs of the shadow on May 22, 1910, and on May 22, 1912, as perfectly identical as would be necessary to convince any jury. He would also, I am sure, endorse the assertion that within one minute of twenty-one and a half minutes after three o'clock on May 22 of any year, the shadow would be as accurately in the identical spot as any eye could see by comparing the original photograph with the reality. Future verifications are, however, no longer possible, because the building was entirely demolished by the tornado of Easter Sunday, March 23, 1913.

CREIGHTON UNIVERSITY,
OMAHA, NEB.

PLATE VI.

A SHADOW IN THIS PICTURE PROVED AN ALIBI

The shadow is seen at the right, on the building. The object casting it was easily identified, and from measurements was found to be 19·62 feet from it at this time. From the position of the shadow it was computed that the photograph was taken within one minute of 3.21½ p.m., May 22, (1910).



3.20½ p.m. 3.21½ p.m. 3.22½ p.m.

THREE PHOTOGRAPHS OF THE SHADOW TAKEN JUST TWO YEARS LATER, MAY 22, 1912

The width of a weatherboard is 0·37 feet, and the shadow passed over one in 4m. 37s.

THE LIMITS OF KNOWLEDGE

By A. McGill

IT is safe to say that no living creature having the power of making a choice between alternatives is totally without knowledge. To be possessed of freedom of choice, yet be entirely devoid of any guide in choosing, would be a meaningless endowment. The new-born infant has knowledge of what is good for him. I suppose that this knowledge is the inherited endowment of the race. It may be called intuitive or unconscious; a gift from our ancestry. Among the lower orders of animal life we call it *instinct* and it appears to be far more profound and far-reaching with them than with us. Were it not that the monotonous repetition of the same formula from generation to generation gives them away (in vulgar parlance) we should be inclined to look on the ant and the bee, with their perfectly organized communities, as more highly gifted than most vertebrates, or even than our own species.

It must often have occurred to us as a matter of regret, that the acquired knowledge of to-day could not be passed on as a hereditary bequest from one generation to the next in somewhat the same way that the nest-building skill of the bird is transmitted. And particularly do we mourn the death of the accomplished artist, who, though he leaves the world richer in virtue of what he has done, leaves it impoverished inasmuch as he takes with him his power to do. Except the elemental knowledge which guides him to proper choice of food, the human infant has everything to learn, even as had his father before him. What shall compensate him for loss of the inheritance of the beaver which brings with it into the world an inherited knowledge of how to build a dam, or the bee, which is born with so comprehensive and so detailed a knowledge of communal life as makes a university education quite superfluous?

When I assert that the most important distinction between the lower animals and man is *man's craving for knowledge*, I am quite well aware that I take the brute at a disadvantage. It may be that could I put the question before yonder ox, horse or sheep in language which truly conveyed my idea to him he might say, "You do me an injustice! I am indeed desirous of knowing how it is that a good feed of grass, a drink at the stream and a quiet rest and rumination under the spreading beech suffice to change a feeling of discomfort and uneasiness, into one of blissful peace and contentment. But I admit the hopelessness of my longing, and act accordingly. I don't worry —but eat, sleep and grow fat."

Without, therefore, being too dogmatic in the case, I shall simply say that, man himself alone excepted, the animal life of this world gives one the impression of being profoundly satisfied to leave phenomena unexplained.

And when I add that man is the exception, you will understand that I refer to man at his highest and best and most distinctive. For it cannot be denied that the majority of mankind is but little removed from the attitude of the brute in this regard. To roam in search of what he wants, to get possession of it, by fair or foul means, to use it for the immediate satisfaction of natural promptings which, for the most part, he possesses in common with the brute,—these are the too predominant characteristics of the average man. But I would call attention to the essential difference between man, at his best, and the brute at his best.

While yet a child he is not satisfied merely to see and hear and touch. He asks questions, and these questions usually involve the search after the ultimate, more often than not being introduced by the all too-comprehensive and far reaching words: How? Why? Where? When?

His first impulse is to seek the knowledge wanted, *outside* of himself. This is the least laborious way of attaining it. It is the quite exceptional child who sits and broods over the matter that troubles him, just as it is the exceptional bovine who grazes

in the meadow when the haystack is within his reach. And the positive answer given by father or mother is likely to be accepted as final, however far-fetched, faulty or foolish. The childish mind has not yet developed the power of independent and co-ordinated thought, just as the childish limbs are not yet competent to tasks which the adult may find quite easy to accomplish. Happy the boy or girl whose grown-up friends protect, as to his *mental* growth, with the same anxious care that the average parent gives to the *physical* well-being of his off-spring. Happy the child whose simple, yet unanswerable, questionings are met with sympathetic encouragement, and the assurance that, although long time must pass and much work be done by the questioner before a full explanation is reached, yet such full explanation may be forthcoming, in the future, — and perhaps its attainment may be the crown and purpose and justification of the young life embodied in the child himself.

There is a way of replying to the most abstruse questionings of childhood, which does not prejudice judgment or stultify the mind. I have often considered the admirable and beautiful answer which the *Westminster Catechism* gives to the question, "What is the chief end of man?" "To glorify God and enjoy Him forever." It is characterized by a vagueness and poetical beauty that may even act as a stimulus, in later life, to further and eminently fruitful enquiry.

Man is by no means the only animal, however, who has much to learn in addition to his inheritance of knowledge; and the history of our domesticated animals, to say nothing of the trained flea, is proof of the capacity of these creatures to acquire aptitudes and habits from their environment and opportunity.

The desire for knowledge is often spoken of as a thirst. It is a beautiful metaphor, and conveys a most important truth. Our pleasures are but the satisfaction of desire, the quenching of a thirst. It is not a part of my plan to elaborate any theory regarding the education of the young; but I cannot refrain from expressing my conviction of the importance of distinguishing between the presentation of a fact as something to be remember-

ed, and its presentation as a something to be discovered. To tell a child that the earth is a sphere is one thing ; to draw his attention to the gradual disappearance of a ship at sea, or to the shape of the earth's shadow on the moon in eclipse ; or to the uniform sphericity of the heavenly bodies, and to leave him to draw his own conclusion, is quite a different thing, although the resultant in knowledge may be the same. The joy of discovery for oneself is too great and too satisfying to be ignored in making up the sum total of a happy life.

If I am asked to say what knowledge or knowing is, I must reply that it has very different meanings to different people. To know that if I plant an acorn I may expect an oak to grow from it is knowledge ; to know that the successful development of my oak is dependent upon the kind of soil in which I plant the acorn ; upon moisture and sunshine and other conditions—this too is knowledge. If I further investigate the subject, discovering what component parts of the tree are supplied by each contributing factor ; follow the changes taking place while "the young and tender juices are hardened into wood ;" I find a vast satisfaction and pleasure in the study. Continued observation is rewarded by a degree of delight only appreciated by those who have patiently and persistently tried it. And this is equally true no matter which one of the thousand objects around us forms the subject of our study. We are using the senses, which form our endowment, in their normal mode—and pleasure is a natural and inevitable result.

> The world tempts our eye
> And we would know it all ;
> We map the starry sky,
> We mine this earthen ball.
> We measure the sea-tides — we number the sea-sands.

In other words we accumulate a store of facts. A very laudable objective, and the necessary basis of all further knowledge. You will remember how the Professor of the Breakfast Table classifies observers as one story, two story and three story

men. The mere observers and recorders are absolutely necessary for the placing on record of the facts which shall form a basis upon which the classifiers may work ; and these in their turn are needed in order to prepare material for the men of broader grasp and further outlook, to use.

Sometimes we may be tempted to speak lightly of mere observation, as his friends think almost pityingly of the Scarabeist ; but let us never forget that the careful and accurate noting of phenomena is the absolutely necessary condition of all valuable deduction. The star maps, carefully drawn and plotted by thousands of telescopic observers whose names are never heard, are the basis of the brilliant generalizations of a Herschel, a Struve, or a Newcomb.

But a deeper joy is ours when we are confronted with a demonstration of something *not* quite obvious. I remember the indescribable pleasure felt in being able, on geometrical grounds, to satisfy myself that the three angles of a rectilinear triangle must be equal to two right angles — no more and no less. It seemed impossible at first sight, to believe that among all imaginable arrangements of three straight lines to form a triangle, it was not possible to vary the sum total of its angles. I don't think that a greater pleasure can be derived from any intellectual exercise than that felt by the boy or girl who, for the first time, satisfies himself of the truth of Euclid's 47th proposition in Book I. Here we have a deeper pleasure than in the mere exercise of the senses ; we have a reasoned knowledge, — a conviction of the truth of something not obviously true at its first presentation.

Knowledge, in the sense in which we use this word in the case of man, implies recognition of the "*me*" and the "*not me*." Like the old cat in Andersen's fairy tale, we distinguish between *ourselves* and the *world*.

Our various *senses*, as their name implies, are the mechanism through which this consciousness comes to us. The mechanism is essentially a nervous structure with more or less complex apparatus through which the nervous impressions may be received without injury to the delicate nerve filaments concerned. We

are all more or less familiar with the nature of the optic nerve, and the structure of the eye — through which we obtain impressions of color and form : — of the auditory nerve, and the construction of the ear, by whose instrumentality we receive impressions of sound. The olfactory nerve, the gustatory nerve, and the peripheral nerves terminating in the surface of the body, by whose agencies we are cognizant of smell, taste and touch, are all capable of study and investigation with delight, and an ever increasing wonder and awe. By means of these avenues we come into consciousness of another world — in which we live — from which we obtain the various needs of continued existence and comfort — and which is yet something outside of our essential personality. We say — " We and the world," just like the old cat. And naturally and inevitably we set ourselves to find out whatever we may concerning this wonderful world outside of ourselves ; and again, some of us are led to inquire of the world within us.

"We close our eyes, and muse
How our own minds are made,
What springs of thought they use,
How righted, how betrayed."

It may not be uninteresting to consider how much more limited our knowledge of the outer world would be had we fewer senses ; or how greatly enlarged our conceptions and our outlook would be had we more senses than the five that are ordinarily counted. To one born blind, but possessed of hearing, taste, smell and touch, the outer world must be a totally different thing from what it is to us ; although what it would be were the whole race of man blind, we can scarcely imagine, much less truly realize. For the blind man is in companionship with his fellows who see, and he is to some extent vicariously possessed of eyesight — through the descriptions which they can give him. How vague his best impressions are may be judged from the classic illustration of Locke, who, after painstakingly describing a red color to a blind man asked him what his idea of it was. The

answer was that he thought redness to be like the sound of a trumpet.

If we were possessed of four senses only, and lacking sight, and then informed that the missing sense would be granted to us, as by miracle, do you think that we could form any conception of the nature of this sense, or of the way in which it would enlarge our knowledge of the universe, before it had actually come into our possession? My own belief is that we could not, while in possession of four senses, obtain any clear notion of where a fifth sense would lead us. We might even imagine such a thing as an added sense to be impossible, being entirely satisfied with the four senses already possessed by us. Has anyone ever asked himself in what direction, or to what purpose, a sixth sense might be added to the five we now possess? All our knowledge is conditioned by the operation and the scope of these five senses. All our science, all our art, all our philosophy, all our imagination, are bounded by the circumscribing limitations of these five senses. May I suggest a direction in which a sixth sense may supervene,—a thing only made possible by a belief that I see this new sense, in its embryonic stages, already taking form. I refer to what we call sympathy. We cognize our fellow-men as distinct entities,—as not ourselves. We see one in pain, the result of accident or disease, and we feel no pain ourselves. Ah, but suppose our sympathy with our neighbor so intense that his sorrows or his joys induce actual pain or pleasure in us, so that our sympathy becomes a link between him and us, is not this to become endowed with a new sense, whose wonderful power for all social purposes may yet make this world a very different thing? Many of us must have known cases in which the news of a catastrophe involving pain and suffering to others—such as a mine disaster, or the sinking of the *Titanic*—has had the effect of making sleep impossible, has taken away the appetite and has even led to positive illness. When the sense of sympathy becomes so universally developed that the misery of any section of the community shall cause an answering throb of pain throughout the whole social organism,

this earth will become a very paradise. Individuals have been so endowed, and have exclaimed — "No man liveth to himself alone." — These may be the fore-runners, the especially gifted in sympathy, just as our Beethovens, Mozarts and Wagners presage the era of universal appreciation of music, which is surely yet to dawn upon our world.

The immediate operation of the senses gives us knowledge of a kind, we touch something and know it as hard or soft, rough or smooth, — even here, however, we exercise memory, and it is the recollection of previous contacts that decides hardness or smoothness. Through memory and comparison we form judgments — and so habitual is it to interpret sensation that some difficulty is experienced in discovering just how much of our conclusions is attributable to the sense impression, and how much to our judgment. We are all familiar with the experiment in which a pencil or a marble is touched by crossed fingers, thus at once coming into contact with the outside of the third and the inside of the second finger — and how vivid is the consciousness that we are touching two pencils or two marbles, if the testimony of the eyes is excluded. It is unusual to bring about contact of the finger surfaces in question except with two distinct objects, and the sensation is interpreted in the light of wonted experience.

It is often said that our senses may and do deceive us. A little reflection will convince us that our senses themselves are not at fault; but only our interpretation of them. Any stimulus of the auditory nerve, which does not injure the nerve, thereby giving a sense of pain, will produce a sensation of sound. The stimulus may be caused by the vibration of the air due to the swinging of a bell, or it may be due to pressure of inflammed tissue pressing upon the internal ear. We are accustomed to associate certain sensations with a bell; and may interpret the effect of pressure due to inflammation as due to this cause. An ordinary cold may cause so-called "ringing in the ears;" a sudden blow on the head, may act as a stimulus to the optic nerve, and give us to "see stars" as the saying is;

disorders of the stomach may so operate upon the gustatory nerves as to give us "a bad taste in the mouth." In none of these cases does the nerve in question perform other than its normal functions, but our interpretation is wrong; our inference takes into account more than the simple sensation, and our interpretation of the meaning of what we perceive involves memory and judgment as well as sensation. Through memory, it is evidently possible for us to combine sensations that are never coordinated in nature, and this power we call imagination. But the most vivid imagination fails to call into consciousness any combination of simple sensations which are not themselves the resultant of sense impressions. Thus, we may combine heads and bodies and legs into the forms of monsters such as never existed on sea or land; but we cannot endow these monsters with a single organ or with a single attribute which has not been suggested to us by the operation of our senses upon the actual world in which we live. Were it possible for a story teller to conceive the working of a new sense in his characters, and to find language by which he could make his readers follow him, what a wonderful field would thereby be opened to him! Munchausen, Gulliver, even the delightful Alice in her Wonderland would be outdone. For these triumphs of vivid imagination display nothing more than our own sensible world turned topsy-turvy.

What might a new sense tell us about this wonderful world? I have no idea, nor do I think that any living man has an idea. In order to say what the revelation would be, one would need to have the new sense. It might enable us to do with assurance what now we dare not undertake. Imagine, a ship freighted with the blind:—captain, mate, seamen, passengers, all blind. The sound of waves breaking on shore is quite audible; the scent of flowers proves a wind off shore; the taste of the water proves that the ship lies in a river mouth or estuary; birds are caught and by touch are known to be land-birds. And with this knowledge as a guide, the ship is steered in a given direction. Imagine the fear and terror on board; the consciousness of

danger makes everyone tremble, and it is felt that chance plays a large part in the ultimate fate of the ship. Suppose sight to be suddenly restored. Confidence takes the place of fear ; joy is written on every countenance ; the whole aspect of things is altered. And all this, only because a fifth sense has been added to the other four.

But, perhaps, there is no room for a new sense ! The senses we have tell us all about the universe that there is to be known ! The Creator knows no more about it than we know ! His consciousness of his work extends no futther than his five senses reveal it to him ! How absurd ! Let us see into what contradictions and impossibilities, into what incomprehensibilities the most enlightened application of our senses have led us, and thus learn to realize our limitations, imperfections, insufficiency. For while it is unphilosophical to reject indisputable and proved conclusions because we do not like them, because they disturb our serenity, shatter our hopes or run counter to our prejudices, it is not unphilosophical to doubt the accuracy or completeness of a course of reasoning which brings us to results at variance with other results which appear at least equally certain, and which have been reached by other processes of thought, possessing equally sound basis.

Consider the nature of the information directly furnished to us by our sense impressions, conjoined with the operation of memory, comparison, judgment and imagination. We discern so-called qualities — color, extension, hardness, odors, taste and so forth. And we are driven to imagine a something which we call *matter*, in which these qualities inhere, and to which they belong. Of this matter in its essence we know nothing except that it attracts other matter in virtue of an equally unknown something which we call force. For special sorts or kinds of matter this force seems to be specialized, and it may appear as magnetism or electrical attraction ; when operating at very short distance it may appear as cohesion, capillarity, or otherwise ; most notably it is manifested as gravitation. Our investigations have resulted in discovering certain constants which we know as

laws. We say that it varies directly as the mass and inversely as the square of the distance of two attracting bodies. We use the attraction of our earth as a means of stating the amount of this attracting force, and we speak of the weight of bodies, as though this phrase told us the whole story. But when we essay to grasp any clear idea of matter, apart from its qualities, as these are perceived by the senses, the thing eludes us. Certainly extension, shape, hardness, smell, warmth, etc , can afford no idea of matter, the sub-stratum to which we conceive these qualities as belonging to, the *Ding an sich* of Kant.

What of the void, where matter is not? Can we conceive of that? Yet extension implies limitation, boundary. We are forced to think of this matter as varying in density. Has void space no density? Does matter furnish the ultimate boundary of space or is there space beyond the limits of matter? We are involved in a maze from which there is no escape. Surely we are concerned with a subject upon which our data, our fundamental knowledge, is incomplete. We know that there are sounds inaudible to the sharpest ear, movements uncognizable to the sharpest eye. We arm ourselves with wonderfully constructed apparatus, microscope, telescope, seismograph, spectroscope and a hundred more, and we increase a thousandfold the capabilities of the senses we possess, but we know, all the while, that an unrecognized universe lies in all directions, beyond the range of our farthest reaching appliances, and at best, we can merely augment the senses we have. We can get more light because we have a conception of light; more delicate measurements, because we have a sense of extension; but what of the fundamental unknown, required to give congruity to our conclusions? Upon the foundation of our sense impressions, and observant of phenomena in the midst of which we find ourselves, we construct theories to account for what we see. The theory of to-day is discarded to-morrow, because it fails to explain newly discovered phenomena. We make a fresh hypothesis and start once more. The phlogiston theory of Stahl is replaced by the atomic theory of Dalton. Not only does this fruitful hypothesis

serve to render intelligible the changes in matter which are known to chemistry, but it is developed by a Clark Maxwell to account for the changing states of matter. Nay, we even determine the minimum sizes of molecules by a study of the Brownian movement, as witness the most interesting presentation of his researches by M. Jean Perrin, quite recently to the Royal Institution in London. The molecule of hydrogen is demonstrated to weigh the 1·47 of one septilliouth part of a gramme — ($1{\cdot}47 \times 10^{-24}$)! Have we reached the ultimately small? Not only have we got far beyond the possibility of our most powerful microscopes to reveal; but it is beyond the scope of our imagination to conceive such a thing. Yet we cannot conceive anything however small which it is not possible to imagine halved and quartered and again and again divided and sub-divided to all infinity — a finality itself inconceivable. Then come the discoveries of radio-activity, and our conception of a permanent atom is scattered to the wind.

Or, if now we direct our attention to the infinitely large, the interstellar spaces, we equally reach the region of the incomprehensible. Every addition to the power of our telescopes, every added refinement in measurement, pushes further and further the boundaries of vision and compels thought to travel still farther and farther than their revelations till we are staggered and stunned by what we see, and rendered quite dizzy by what we think. We are again in the region of the impossible to be grasped.

Our nature seems to be a double one. On one side we are conscious of boundary and limit; just so far in time, space and weight, and no farther. But, on the other hand we have suggestions of development, unlimited, infinite, ever aspiring to comprehend an ever expanding universe. And our conceptions of the world without us correspond to these two discrepant and contradictory sides of our nature. We have the crystal, with its exactly defined planes and edges and angles, and we have the cell with its unlimited tendency to growth and proliferation, typifying these two antithetic modes of thought. There seems

to be no direction in which we can pursue a train of thought, starting from fundamental conceptions supplied us by the simplest mental operations upon direct sense impressions, which does not lead us sooner or later into a blind cul-de-sac.

Nor are we any better off when we leave the region of natural phenomena without us, and consider things of the mind. We become aware of our own personality, sooner or later. We are convinced of our own being and existence as something peculiarly our own. We, the essential WE, are outside of things — but were we always so? Where were WE before we became conscious of our existence? Had we any being at all before we were aware of it? Were WE — the essential ego — a part of an undiscerned world without — as certainly our bodies were a part of what we call the material world outside of ourselves? Our bodies were bread and butter, beef and mutton, before they became ours — and there is just so much less bread and butter in the material world at this moment as corresponds to the equivalent which we call our bodies? Was it so with the real ego! Did it exist while yet we knew it not — or was it a new creation at the moment of our birth into consciousness? We have our doctrines of conservation of matter and energy. Do matter and energy comprehend ourselves? Is the ego but a discrete part of some undiscerned ocean of being, as a drop of dew on a rose-leaf is but a part of the ocean, come into objective separateness as we may conceive ourselves come into subjective consciousness from an ocean of consciousness lying beyond our ken? If so, are we, like the dew-drop, doomed to be again swallowed up in the universal consciousness from which we have emerged, or may we hope, through endless æons, to retain the individual consciousness which we now possess!

The testimony of such senses as we have is not in the direction of giving us confidence in the permanence of individual entities. Quite the contrary seems to be the order of the universe as we are able to appreciate it. Is this change progressive or retrogressive; is it towards betterment or towards degeneracy? Is it upwards or downwards? On this matter the world is divided

between the optimist and the pessimist; and, based upon the knowledge which our most highly developed senses give us, each class is able to put up a strong argument — perhaps, we may even say, a conclusive argument — thus bringing us once more face to face with contradictories, both of which cannot be true. The only way out would seem to be an acknowledgment that our fundamental data are insufficient, or that there is something wrong in our method of using such data.

Then we are told to have faith; but faith in what? Could we find an individual or an organization possessed of means of acquiring knowledge over and above those possessed by ourselves, we should certainly be tempted to acclaim such fortunate beings, and to welcome them as our instructors and guides; just as the ship manned by a blind crew would welcome the arrival of a pilot who could see. But where are these capable guides?

> "A hundred doctors try
> To preach thee to their school;
> We have the truth, they cry,
> And yet their oracles.—
> Trumpet it as they may, is but the same as ours."

This universe as our senses reveal it to us, is our *milieu*; we must perforce work within its limitations. Perhaps death does not end all; perhaps we may yet be endowed with avenues of knowledge, whose possession shall enlarge our horizon beyond the limits of dream. What we know not now, we may know hereafter. What now form the enigmas, the perplexities, the dilemmas, the contradictions of life, may yet be seen in a true perspective and a finished detail, as worthy of a god.

Meantime, what an infinity of joy is available to us here and now! The senses we possess give us consciousness of ourselves and of the *not* ourselves. From this consciousness come all our desires, all our aspirations, all our hopes — yea, and our faith also. We have no choice but to accept this consciousness and to live in it. And somehow there is borne in upon us a

conviction that as we have already received so much, then shall somewhere and somewhen be given yet more to us.

> We have but faith; we cannot know;
> For knowledge is of things we see;
> And yet we trust it comes from thee,
> A beam in darkness; let it grow.

But I must not close this address without attempting to express, however imperfectly, my conviction of the meaning and value of what may be called scientific procedure with a view to knowledge. Granted that we live in a world of appearances only; that we know nothing of the reality behind all this seeming; that even space and time are merely forms in which we clothe our thought; it is still, I believe, an easy thing to convince ourselves of the great value and importance of scientific study. So far back as Protagoras (400 B C.) it was taught that the world which we know is not the world as it is, but only the world as we perceive it. This world we recognize as matter and mind — the former perceived by our senses, the latter by our emotions. There is some justification, and much wit, in the oft heard epigram — What is the matter? Never mind! What is mind? No matter! — At least we know they are distinct, and not overlapping. Except in that minute fragment of the material world which we call our body, and which is subservient to our *will*, we know the world without us to be independent of us. My will is able to influence my body — but there its power over the outer world ceases. In vain I wish the wind to cease blowing, or the rain to cease falling. My wish can raise my arm or bow my head — but it has no power to raise your arms or move your heads. My will cannot, by the mere act of willing, cause one stone to place itself above another, or make a wheel go round. And yet we do place stones one upon another to build sky-scraping edifices, and millions of wheels are at this moment turning because we will that they should do so. How is the wonder wrought? Through the instrumentality, the agency, of that minute portion of matter — man's body — upon which his will directly operates, he has been able to control and operate

upon that other world of matter which does not directly acknowledge his supremacy or obey his command. The ego, the *me*, is the fundamental entity, the essence of personality — but only its incarnation gives it a place, a *status* in the world as we know it here and now.

Whence came the longings, the fears, the likes and dislikes, the preference and the aversions of this soul of ours? Shall we ever know why we call some things beautiful and others ugly? Some actions noble and other ignoble? Some courses of conduct worthy and others unworthy? Is it habit, resulting from repetition or usage that makes a thing pleasant or agreeable? The ticking of a clock disturbs us, we wish it removed from the room. But we tolerate it, and soon cease to notice it. One day it stops, and we are unpleasantly conscious that something is wrong. We are glad to set it going once more. Perhaps that is why we like sugar in our tea, or to witness a heroic action performed. Racial differences of face and form doubtless determine different ideals of personal comeliness. Even vice, presenting itself to us as a monster of frightful mien needs but to be seen often enough to be first endured, then pitied, then embraced. To see a thing repeated and re-repeated is to suggest a rule or law — and a careful study of the conditions of repetition has resulted in the discovery — within the world as we are able to cognize it — of what we name *natural laws*. These natural laws are nothing more than the recognition of ordered sequence. They are no pretensions to knowledge of the ultimate, no assumptions to explain the fundamental, the origin or the end of life. They are strictly a working within the circumscribing environment in which we live. So might an intelligent mole, operating underground, and within the limits of the only world he knew, discover and formulate his varied experience for the benefit of his fellow-moles, and for the satisfaction of his own enquiring mind — yet hesitate to aver that the earth in which he worked, the dirt which he tunneled and displaced for his own convenience, must extend infinitely upwards and downwards, and on every side of him. If changing pressures and temperatures, and the

faint suggestions of luminosity that reached him, gave him hints of a universe quite different from that in which he lived, he could scarce help speculating and imagining something of its nature, but the only terms in which he could either think or speak, having been evolved by acquaintance with mud and darkness, it is certain that his guesses would be but travesties of the truth. Yet that within his *milieu*, even a mole may be happy, who can doubt?

And, for us, accepting our limitations, and daring not to be presumptuous, what vast material for enjoyment lies within our ken. We may not add one cubit to our stature by the intensest thought — but we may make ever better use of the stature we have.

What for exampie is scientific terminology but a means of condensing and arranging our knowledge so as to make a brief symbol stand for a complex thought. To use an illustration adduced by Dr. Zart in a recent address; we hear the voice of a friend in the darkness. That single sound brings our friend with all the thousand associated ideas which constitute him such into our minds. Just so do the symbols of mathematics, the name words of science, become the means of bringing up complex ideas to us. But unless we know our friend intimately the suggestion of his presence means but little to us — in other words the symbol can only call up to memory such knowledge as we possess about the thing signified. Too many are satisfied to have the symbol stand for nothing, or next to nothing. Here is the essential difference between the scholar and the ignorant man; here is the reward of study. And the boundaries of the known and the joy of reaching out after further knowledge, expand as we proceed. We make things thinkable by our theoretical assumptions — we explain the apparent movements of the heavenly bodies by geometrical constructions and the principles of dynamics; we render intelligible the changes which chemistry discloses by a theory of atomic and molecular structure — but we know that our most helpful theories do not get to the root of the matter, and require constant revision and modifica-

tion as our further experience reveals new knowledge to us. But they do help us ; and that they serve to bring us nearer to the truth is evidenced not only by their indicating the direction of further research, which is rewarded by discovery, but they serve practical ends and make our every day life richer and fuller by their application.

And if our ever growing scientific conceptions should remain no more than artistic productions, yet are they the greatest and the most sublime that the mind of man can reach. We touch the borderland of the known, and our minds seek to go beyond that — far, far beyond the limits of what we can express or even think in terms of science. Here we enter the realm of the poet, and poetry is properly employed upon material too vaguely grasped to admit of definite expression. Yet is the world of the poet no less real than that of the scientific investigator, the mind and soul of man is far more truly the essential of his life than the material universe can ever be. Yet is there a close connection between the two ; and together they furnish him with all that life can mean to him. I can give no better illustration of what my meaning is than by quoting those majestic lines of Wordsworth, written at Tintern Abbey.

> Once again
> Do I behold these steep and lofty cliffs,
> That on a wild secluded scene impress
> Thoughts of more deep seclusion ; and connect
> The landscape with the quiet of the sky.
>
> To them I may have owed another gift,
> Of aspect more sublime ; that blessed mood,
> In which the burden of the mystery,
> In which the heavy and the weary weight
> Of all this unintelligible world,
> Is lightened ;—that serene and blessed mood,
> In which the affections gently lead us on,—
> Until, the breath of this corporeal frame
> And even the motions of our human blood
> Almost suspended, we are laid asleep
> In body, and become a living soul :

While with an eye made quiet by the power
Of harmony, and the deep power of joy,
We see into the life of things.

For I have learned
To look on nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh nor grating, though of ample power
To chasten or subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts: a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean, and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things.

OTTAWA, ONT.

SIR GEORGE HOWARD DARWIN

By Alfred T. DeLury

ON December 7 last there passed away Sir George Darwin, one of the ablest astronomers of our day. His original investigations had meant real acquisitions and had quickened astronomical research along certain important lines; his teaching had attracted to his science and stimulated a considerable band of younger writers; and his popular expositions, though too few, had revealed to the many who are interested in astronomy the significance of the discoveries in which he was interested. He had thus become endeared to an unusually large circle, now called upon to mourn the loss to science with an added element of personal grief.

George Howard Darwin was born in 1845 at Down in the County of Kent. He was the second son of Charles Darwin, who in 1842 had chosen to live at Down as affording the quiet necessary to his health and his studies and researches, and the advantage of nearness to London with all its scientific interests and activities. Recalling that his father's great work, "The Origin of Species," was published in 1859, we see that he was born into an atmosphere charged with ideas; and that when at an age at which his mind would naturally be asserting his character, he found himself amid the din and controversy attendant upon a revolution in scientific thought. The influence of these things upon the trend of his development would seem to be manifest.

At school he was a pupil of Charles Pritchard, afterwards Savilian Professor of Astronomy at Oxford, and here his attention may have been given a turn in the direction of mathematics and astronomy. He entered Trinity College, Cambridge, in 1864, and followed the course prescribed for the Mathematical Tripos, being ranked second wrangler on graduation in 1868.

PLATE VIII.

GEORGE HOWARD DARWIN (about 1901)

Born, July 9, 1845. Died, December 7, 1912.

This course, whatever its weaknesses or defects may have been, had the merit of assuring to the student, who followed it seriously and well, a thorough acquaintance with the methods and results of mathematical physics, a knowledge of which was essential to the investigations that were to claim his attention.

Though on making his degree he was appointed to a fellowship in his college, he discontinued his scientific studies, and, like Cayley and Sylvester, turned his attention to the study of law. He was called to the Bar in 1874, but, like them, returned unreservedly to his science. Cambridge again became his home, and in 1883 he was named to the Plumian chair of astronomy and experimental philosophy.

At this time he was well advanced along one of his lines of study, the theory of the tides, a subject which, on account of its incompleteness and difficulty, has made demands on the best energies of nearly all dynamical astronomers. William Thomson, afterwards Lord Kelvin, had sought to apply to the tides a method of analysis similar to that employed in the lunar and planetary theories, and had submitted, in a series of reports to the British Association, the results of the analysis of tidal observations. The work of Kelvin was taken up and continued by Darwin, associated with Adams, and he prepared a number of reports and papers of distinct practical and theoretical value.

Closely related to these studies on actual tides, is a series of investigations on tidal friction and its bearing on cosmogony or cosmic evolution. In one very important paper, "On the Precession of a Viscous Spheroid, and on the Remote History of the Earth," he considers at length the relation of the moon to the earth and states that his speculations "point strongly to the conclusion that, if the moon and the earth were ever molten viscous masses, they once formed parts of a common mass." He further observes that this leads "at once to the inquiry as to how and why the planet broke up. The conditions of stability of rotating masses of fluid are unfortunately unknown, and it is, therefore, impossible to do more than speculate on the subject." Later, as we shall see, he was in a position to extend his investi-

gation still farther back. Throughout this set of papers the guiding purpose was to realize the details of planetary development and to explain the anomalies in the generally accepted theory presented by the solar system. The facts of the solar system are taken as initial conditions, as it were, and the dynamical theory under certain hypotheses is carried back and made to render precise the probable early conditions. In the more extensive memoirs the author gives an illuminating summary and discussion of the results of the investigation. From one of these summaries a few paragraphs may well be quoted :—

> "In the following discussion I shall accept the nebular hypothesis in its main outline, and shall examine what modifications are necessitated by the influence of tidal friction.
>
> "From a consideration of numerical data with regard to the solar system and the planetary sub-systems it appears improbable that the planetary orbits have been much enlarged by tidal friction since the origin of the several planets. But it is possible that part of the eccentricities of the planetary orbits is due to this cause.
>
> "From arguments similar to those advanced with regard to the solar system as a whole, it appears unlikely that the satellites of Mars, Jupiter and Saturn originated very much nearer the present surfaces of the planets than we now observe them.
>
> "The numerical data exhibit so striking a difference between the terrestrial system and those of the other planets, that, even apart from the considerations adduced in this and previous papers, we should have grounds for believing that the modes of evolution have been considerably different.
>
> "This series of investigations shows that the difference lies in the genesis of the moon close to the present surface of the planet, and we shall see below that solar tidal friction may be assigned as a reason to explain

how it happened that the terrestrial planet had contracted to nearly its present dimensions before the genesis of a satellite, but that this was not the case with the exterior planets.

"That the interior satellite of Mars revolves with a period of less than a third of its planet's rotation is, perhaps, the most remarkable fact in the solar system. The theory of tidal friction explains this perfectly, and we find that this will be the ultimate fate of all satellites, because the solar tidal friction retards the planetary rotation without directly affecting the satellite's orbital motion.

"From the discussion in this paper it will have been apparent that the earth and moon do actually differ from the other planets in such a way as to permit tidal friction to have been the most important factor in their history."

These detached statements afford an indication of the problems that engaged the attention of Darwin in the papers under consideration.

A kindred series of papers, supplementing the investigations already mentioned, are the memoirs on the figures of equilibrium of a rotating liquid. For a long time the spheroid, had been regarded as the one stable form of equilibrium of a rotating liquid. Jacobi had shown that the changing spheroids, under contraction and increased angular velocity, tended to a limiting form through which they passed into a new series of figures with three unequal axes. The theory halted here, until Poincaré, taking up the study of possible forms, showed that the Jacobian series tended also to a critical stage through which they in turn passed into a new series of pear-shaped figures. This sequence moreover tended to a critical stage in which the smaller stem part of the pear-shaped figure was ripe for a separation from the major part. Poincaré's papers appeared in 1885. Darwin had, from quite a different point of view, been led to entertain a similar view. The results were of first importance

to him for they allowed him to introduce the initial stage necessary to his application of his theory of tidal friction to the earth-moon system. The pear-shaped figure passed to the rupture or separation stage, and from that point onward the way was clearer, though at the outset a series of changes must occur which are quite unknown.

In 1887 Darwin was asked to deliver the Lowell Lectures in Boston and he chose as his subject "The Tides." The substance of these lectures appeared in 1898 in a volume of the same title. In this work, in addition to giving a general account of the nature of tides and tidal observations and predictions, he gives a most lucid account of the theories that have here been described. The treatment combines in almost unequalled degree the popular and the scientific. This and his famous Presidential Address to the British Association have been read and studied by almost everyone interested in astronomy.

As has been indicated, the greater part of Darwin's work, intrinsically valuable as the individual papers are, can be seen to converge on the great problem of cosmic development. At first he accepted with slight reserve the hypothesis of Laplace. His own investigations introduced modifications of the theory based on the hypothesis, but there remained difficulties, dynamical and physical. With open mind, he examined each new suggestion, and one of the most interesting of his papers, "On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony," was written to show "that by a certain interpretation of the meteoric theory we may obtain a reconciliation of these two orders of ideas (*i. e.* the nebular and the meteoric theories), and may hold that the origin of stellar and planetary systems is meteoric, while retaining the conception of fluid pressure." The theory advanced by Chamberlin and Moulton, and known as the planetesimal hypothesis, also claimed his attention, and in the new edition of "The Tides" he devotes the greater part of a chapter to a general explanation and examination of this theory.

Darwin's special knowledge, and his interest in actual prac-

tical problems, led to his being named to several important public or international services. He represented the Royal Society on the British Meteorological Council, and on the Indian Survey, and the British Government on the International Geodetic Association. His election to the presidency of the British Association in 1905, and to the presidency of the International Mathematical Congress in 1912, and the award of the Copley Medal for 1911, alike testify to the outstanding place he held in his science.

The meeting of the Mathematical Congress under his presidency was held at Cambridge in August last. His address, though brief, was full of interest and reflected the man,— his genuine modesty in the matter of his own achievements, and the generous recognition of the work of others. Those who knew him well were aware at the time that he was not in his full physical strength, yet few of those present were prepared for the word that came to them in December last. In his death Cambridge lost a distinguished son, and astronomical science one of its foremost investigators, one who, "burdened by a mighty name" had added to that name a new glory.

MEETINGS OF THE SOCIETY

AT TORONTO.

February 18, 1913.—The meeting was held in the Society's Rooms, 198 College Street, at 8 p.m. In the absence of the President, Professor C. A. Chant occupied the chair.

Dr. G. L. Palmer and Mr. E. G. Wilson, of Toronto, were elected members of the Society.

Professor Chant gave a short synopsis of communications received regarding the display of meteors on the evening of Sunday, February 9th, 1913.

Mr. A. F. Miller gave an account of observations on an abnormal fall of the barometer on January 3rd, with illustrations of the meaning.

Mr. W. E. W. Jackson, M.A., gave the lecture of the evening on "A Recent Trip to the Hudson Bay District and the Magnetic Observations in that District." Previous trips which had been made by Mr. Jackson were first briefly described by him; and the method used of obtaining magnetic elements was carefully and clearly shown.

With the assistance of a map a detailed account of the trip was given including an interesting description of the difficulties which had to be contended with, and outlining the observations made of the values of the magnetic element at different points on the voyage.

March 4.—The regular meeting was held at the Rooms, 198 College Street, the President being in the chair.

Mr. Harry J. Lane gave the paper for the evening on

"Ancient Superstitions regarding Meteorites and Shooting Stars." Our knowledge of meteoric bodies and the records of their appearance as described by various observers from ancient to modern times was sketched by the lecturer and the manner of determining their paths in the earth's atmosphere was lucidly described. Mr. Lane pointed out that with some knowledge of the constellations and equipped only with a straight wand and a chart of the visible heavens, a careful observer, when the skies are clear enough to allow celestial objects to be seen, might be able to do some useful work in tracing the "radiant" of whatever meteors might appear.

The paper was discussed, and the hope expressed that a number of the members would associate themselves in making observations of this kind with Mr. Lane.

March 18.— The meeting was held in the Rooms of the Society, 198 College Street.

Professor A. T. DeLury, M.A., gave the lecture of the evening on "Sir George Darwin." George Howard Darwin was the son of the distinguished naturalist Charles Darwin, who, at this time and for the next thirty years was in the midst of his greatest work.

The lecturer gave an account of the early life and education of Sir George Darwin and then of his subsequent life in the practice of law and his later academic life at Cambridge as Plumian Professor of Astronomy and Natural Philosophy. Then followed an account of his work on the tides and tidal friction, and a clear description of the effect of tidal friction on the system of the earth and moon.

In conclusion the lecturer gave an account of Darwin's work in connection with scientific organizations. He contributed frequently to the proceedings of the British Association, and was President for the meeting in South Africa. He was also connected with other scientific and mathematical societies.

The paper was discussed by Dr. A. D. Watson, Mr. J. H. Mason and the President.

L. G.

At Hamilton

February 28.—At the regular meeting held this evening, Victor Taylor was elected a member of the Society.

The lecture of the evening was by Mr. John A. Paterson, M.A., K.C., on "A Recent Visit to Greenwich Observatory."

This was much enjoyed. The history and work of the institution were described in a manner to make all proud of our national observatory. The illustrations also gave a vivid idea of the place where work of so much importance is carried on.

March 28.—Henry Westoby, Esq., President of the Guelph Centre, lectured before the Hamilton Centre this evening on "Life in the Other Worlds."

Pointing out the dependence of our world on the energy supply from the sun, it was shown how the conditions on this earth had changed from age to age and yet life was able to accommodate itself to the varying environments through the geological ages.

So could life accommodate itself to the different conditions existing on other planets.

The lecturer passed in review the various members of the solar system, pointing out why some were supposed to be possibly fit for habitation while others were not. Then passing in to the universe of stars it was asked, Is it probable that among such a host of suns not one should be attended by planets fit for the abode of life?

The lecture was profusely illustrated by lantern slides and was highly appreciated.

T. H. W.

At Peterborough

March 13.—Mr. H. Westoby, of Guelph, gave an address on "The Adaptability of Life to its Surroundings and the Possibility of its Existence on Other Worlds." The subject was discussed in a clear concise and well thought out scheme, illustrated with a fine series of lantern slides.

Beginning with a sketch of the conditions inferred to have

existed at the period of time when the globe was in a state of vapor, he traced the gradual development through successive stages of formation, assigning to each its geological characteristics, down to the time when the earth would be in such a stage as to sustain life in the higher forms. All of this was stated in a most interesting narrative with explanatory reference to the several slides depicting the grotesque form of animal life, and such as revealed by the evidence disclosed in the earth's strata and in the remains of the animals found from time to time. The story of the physical creation of the world and its denizens was brought down to within an appreciable period as measured in years as we now compute them.

Turning to the question of the possibility of life on other planets, Mr. Westoby said that of this we only had conjecture, but we could reason out, from known conditions under which life existed on the earth, what condition would need to be existent on other planets. Frankly speaking he said that so far as years of investigation and research could extend there was little or no probability that life, in any such form as we know it, existed. In case of one or two planets there was some slight probability, but the essentials of heat, light and air were so varied, because of physical reasons, that life analogous to that of human beings was hardly to be thought of. The lecture closed with an expression of confidence in the belief that behind the creation of the universe, there must have been and is a Wise and All Governing Power.

The thanks of the meeting was tendered Mr. Westoby for his interesting address.

D. B. M.

At Guelph

January 24, 1913.—The meeting was addressed by Dr. C. A. Chant, of the University of Toronto, on the subject "Dark Stars: The Astronomy of the Invisible." The lecture was very instructive and entertaining and illustrated by excellent lantern slides.

The heavens contain a vast amount of visible matter, but, said the lecturer, the invisible is, perhaps, more important than the visible. There probably exists a wealth of unseen matter, that surpasses comprehension. This conclusion is reached in several ways. Firstly, we can estimate the amount of energy performed by the sun in horsepower. This is unthinkable in immensity. The sun cannot keep up this loss of energy forever. It must diminish in heat-giving power and finally became a dark or invisible body.

Secondly, the suns, or stars, are of different colors, some emitting white light, some yellow, some red. Our sun is yellow. The difference in appearance is an indication of physical condition, as is shown by a coal, which, white hot from the furnace, passes through a gradual change from white to yellow, then to red, then goes out. In like manner many suns must have gone out.

Further, the spectroscope assists the eye in determining the color value of light from the stars, and the nature of the gases that give rise to these colors. Photography gives additional assistance in determining age. The Pleiades are white, and photography shows that they are enshrouded in nebulous matter. They are probably in the process of making. Vega is white, Capella and Arcturus are yellow, Betelgeuse is reddish, and others are still redder.

Again, many stars are found to have companions which are far on towards extinction. Their presence is indicated by the peculiar motions of the visible star as well as by double lines and displacement of lines in the spectrum.

Still another proof of the presence in the heavens of invisible matter is given by the so-called "shooting stars" or meteorites. These solid and ordinarily invisible bodies are very numerous.

At the close of the lecture the appreciation of the audience was expressed by the chairman, Professor W. H. Day, and a hearty applause was given by the audience.

February 25.— An address was delivered by Mr. H. Westoby, the President of the Centre, on the subject, "The Adaptability

of Life to its Surroundings and the Possibiliy of Its Existence on Other Worlds." The lecture was illustrated with a splendid series of lantern slides.

The speaker explained the theory of the world's formation, its gradual diminution in size and loss of heat, and showed at what temperature it was probable that the earliest animal life existed. He traced the gradual development of the world through the varying stages of its formation and showed by illustrative slides what animals belonged to each period according to information obtained from fossils and other remains of prehistoric life. The lecturer showed how life in various ages and various places was adapted to the conditions which surrounded it.

With reference to the other part of his subject, the speaker explained how the conditions on the various planets are different in respect to atmosphere, temperature, and light. The planet Mars conforms most nearly with the conditions that prevail upon our earth. There may be life on Mars. But some of the planets are still in the gaseous state or are red-hot, and we may positively say that no life exists in such planets, at least as we know it.

A hearty vote of thanks was accorded to Mr. Westoby for his very interesting address.

J. T. L.

At Winnipeg

March 7.— A most interesting and instructive lecture on "Popular Astronomy" was given in the University of Manitoba, by C. H. Gingrich, B.A., Ph.D., Professor of Astronomy in Carleton College, Northfield, Minnesota. Dr. Gingrich is associate editor of *Popular Astronomy*, one of the best known astronomical journals of to-day.

The subject of the address was "Modern Methods of Stellar Photometry." He pointed out that stellar photometry is concerned with the problem of finding the brightness of the stars. The brightness of stars is measured in terms of a unit called "magnitude." This term was first introduced in this connec-

tion when it was thought that the brightest stars were also the largest, an idea which has been found to be erroneous.

Even before the days of telescopes the differences in the brightness of the stars attracted the attention of astronomers, and we find them classifying the stars according to their magnitudes. With the introduction of the telescope, and the consequent increase in the number of stars to be studied, the methods of determining the brightness of the stars were improved; but the basis of classification, with slight modification and considerable extension, is the same now as it was in the time of Ptolemy and Hipparchus.

At various times within the last century, large catalogues containing hundreds of thousands of stars have been made, in each of which the magnitude of each star is given. The mammoth telescopes of to-day reveal stars from which only one-millionth of the light of some of the brighter stars reaches us.

In modern times the interest in star magnitudes has been increased because of the discovery of numerous variables, or stars whose light is not constant, but changes, in some cases very rapidly, in others very slowly. Much can be learned regarding such stars by a study of the character and rate of their changes. And these can be determined only by comparison with stars near by which do not change. The magnitude of these stars must be known very accurately if they are to serve their purpose as standards for comparison. Much work has recently been done in this very field, and Dr. Gingrich himself has contributed very extensively to our knowledge of it.

The introduction of photographic methods into astronomy brought new ideas into the work of stellar photometry. It was soon found that there is one scale of star magnitude based upon visual determinations and a different scale based upon photographic determinations. These two scales have been found to be related through the spectra of the stars, through their color.

We usually think of Sirius as the brightest star in the sky. But the sun has all the characteristic features of a star, and properly belongs to that class of celestial objects. It is relatively

near to us and hence seems so much larger and brighter ; but it would appear very much fainter than many stars in the sky if it were removed to the distance they are from us.

It is sometimes stated that the light and heat of the sun are diminishing. The fact that these statements are still subject to question is proof that if there is any decrease it is very small, and, for several millions of years at least, the sun will continue to furnish the necessary warmth and light to the members of its family, of which the earth is one.

March 19.— The President was in the chair.

Notes on current astronomical phenomena were presented by several members and in particular Mr. Malpass called attention to the total eclipse of the moon to occur on the morning of March 22nd.

An address was then delivered by Mr. H. C. Howard on "Nebulæ."

On the star map of Ptolemy some cloudy or nebulous stars are shown, all of which, however, have since by the aid of the telescope been resolved into star clusters.

But the telescope reveals many cloudy masses which even the highest power cannot resolve. Forty years ago it was supposed that the only distinction between star-clusters and nebula was their relative remoteness. Huggins by the aid of the spectroscope found that some nebulæ are gaseous and it is now admitted that star clusters and nebulæ are quite distinct.

The first catalogue of nebulæ was compiled by Sir William Herschel who noted that many were spiral in shape. Since then several successive catalogues have been published and the number of recognized nebulæ now reaches many thousands.

The nuclei of spiral nebulæ are white while in other nebulæ they are greenish.

One of the most remarkable of the spiral nebulæ is the great nebula in Andromeda which is visible to the naked eye. The diameter of this nebula is estimated at over 500,000 times the distance from the earth to the sun.

Besides spirals, nebulæ are classified according to shape as irregular, of which the Orion Nebula is a striking example; Annular Nebula, Dumbbell and Planetary Nebulæ.

The generation of spiral nebulæ has been attributed to the disentegration of two stars owing to tidal strain resulting from their near approach.

Little is known of the constitution of nebulæ but by the aid of the spectroscope it has been possible to detect the presence of hydrogen, helium and a gas not hitherto found elsewhere and which has been called nebulium.

A change has been noted in the so-called Trifid Nebula in Sagittarius, a bright star which is described by Herschel as then being in the middle of one of the central lanes is now in the edge of the nebulous mass.

The address was well illustrated by a large number of lantern slides.

An interesting discussion followed after which the meeting adjourned.

C. E. B.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

February, 1913

Temperature.— The mean temperature for February was below the normal over Canada, except in Saskatchewan and Alberta. The weather was decidedly cold in British Columbia, the negative departures ranging from 3° in the vicinity of Vancouver to 11° in the southern interior. It was also decidedly cold in Northern Ontario where in some localities the mean temperature was 9° below the normal. In the more southern portion of Ontario and in Quebec and the Maritime Provinces the negative departures ranged between 1° and 5°. In Saskatchewan and Alberta the positive departures ranged between 3° and 5°.

Precipitation.— The precipitation for the month was above the normal in the vicinity of the Georgian Bay and in some localities in Nova Scotia. The total fall in the Prairie Provinces did not differ much from the average but in other parts of the country the average value was not reached. The precipitation was particularly light in the counties bordering on Lakes Erie and Ontario, where at some points only about half the usual amount was recorded.

March, 1913

Temperature.—Unseasonably cold weather prevailed during March from the Pacific Coast to Lake Superior, while elsewhere in Canada the temperature was in excess of the normal. Negative departures in Manitoba were large, being from 6° to 9°,

and in Saskatchewan and Central British Columbia reached 4° and 5°. Positive differences from Lake Huron to the Maritime Provinces were generally above 2°, and reached 5° in Nova Scotia.

Precipitation.— Precipitation exceeded the normal in the Cariboo District of British Columbia, southern districts of Alberta and Saskatchewan, and from Ontario to the Maritime Provinces with the exception of the Gaspé Peninsula of Quebec and Cape Breton Island in Nova Scotia where the average value was not reached. In northern districts of Alberta and Saskatchewan, and throughout Manitoba there was a marked deficiency, especially in the latter Province where the total fall was a mere fraction of the normal amount. The excess from Ontario to the Maritime Provinces was pronounced.

Temperatures for February and March, 1913

Station	February		March	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	20	-40	30	-36
British Columbia				
Atlin	38	-18	48	-16
Agassiz	48	20	59	17
Barkerville	39	-24	54	-18
Kamloops	42	16	52	6
New Westminster	47	18	55	18
Prince Rupert	54	22		
Vancouver	48	21		
Victoria	50	27	64	24
Western Provinces				
Battleford	46	-32	50	-26
Broadview				
Calgary	57	-18	56	-12
Carman				
Edmonton	50	-32	53	-15
Medicine Hat	51	-23	58	-18
Minnedosa	31	-34	44	-29
Moose Jaw	43	-24	53	-26
Oakbank	28	32	45	30
Portage la Prairie	31	-30	42	-27
Prince Albert	40	-38	48	-30
Qu'Appelle	41	-29		
Regina				
Swift Current	46	-27	54	-18
Winnipeg	28	-28	46	-26
Ontario				
Agincourt	53	- 5	63	- 6
Aurora	44	-11	61	- 9
Bancroft	45	-27	57	-21
Barrie				
Beatrice	40	-30	57	-17
Birnam	51	- 1	65	-10
Bloomfield	45	13	61	- 7
Brantford	55	- 1	70	- 5
Bruce Mines	39	23	49	-28
Chatham	57	- 2	78	- 1
Clinton	45	1	63	- 9
Cottam	56	10	78	- 8
Gravenhurst				
Guelph				
Haliburton	42	-31	58	-19
Hamilton				
Huntsville	39	-37	55	-15
Kenora	28	-33	49	-34
Kinmount	46	-38	58	-26
Kingston	44	-16	57	7
Lakefield				
London				
Lucknow	46	- 4	62	- 9
Madoc	48	-15	61	-15
Midland				
North Gower				
Otonabee				
Ottawa	37	-18	61	-15
Owen Sound				
Paris	52	- 4	70	- 8
Parry Sound	39	-24	56	-19
Peterboro'	47	-17	63	-10
Port Arthur	30	-23	49	-17
Port Burwell	47	- 2	56	- 6
Port Dover	50	- 1	60	- 5
Port Stanley	45	- 1	52	- 6
Ronville	39	36	56	-18
Sarnia				
Southampton	47	14	61	- 5
Stonecliffe	36	-32	56	-22
Stony Creek	56	4	67	- 3
Stratford				
Toronto	53	- 1	64	- 2
Uxbridge	44	24	61	- 9
Wallaceburg	52	- 3	66	- 7
Welland	52	3	68	- 4
White River	30	42	56	40
Quebec				
Brome	46	-27	63	-10
Father Point	42	-14	58	- 2
Montreal	40	-12	62	- 4
Quebec	34	-17	56	-12
Sherbrooke				
Maritime Provinces				
Charlottetown	46	-14	54	- 2
Chatham	50	-16	64	-11
Dalhousie	35	-23	48	-13
Fredericton	38	20		
Halifax	50	-21	70	3
Moncton			66	- 6
St. John	43	-11	52	- 5
St. Stephen	46	-20	58	-20
Sussex			63	-10
Sydney	59	-11	58	2
Yarmouth	48	2	55	8

Earthquake Records by the Milne Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1913	P. T. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Durat.	Remarks
		h m	h m	h m	h m	mm.	h m	
1227	Feb. 7	3 45·2	4 5·6)	4 15·1?	4 58·5)	0·3	1 13·3)	
			4 9·8)		5 20·0?)		1 34·8?)	
1228	" 18	0 55·8	0 57·8	0 58·7	1 12·8	0·2	0 17·0?	
1229	" 20	9 19·6?						
		9 22·4			9 25·6?	0·05	0 6·0	
1230	" 23	3 11·6	3 17·8	3 21·1	3 43·6	0·2	0 32·0	Eq. reported
			3 19·9					from Ecuador
1231	Mar. 3	3 18·4?	3 24·7		3 27·4	0·1	0 9·0	
1232	" 4	11 37·7			12 8·4	0·05	0 30·7	
1233	" 6	12 2·5?	12 6·0		A C	0·1		
1234	" 8	16 1·4?	16 7·7	16 10·2	17 17·2	1·8	1 15·8	Guatemala eq.
	" 9	A C	10 to 17					
1235	" 10	14 55·8			15 10·4	0·1	0 14·6	Eq. Celebes.
1236	" 14	No Pts.	9 7·3	9 19·9	10 23·0	0·9	1 15·7	[107 persons
1237	" 15	22 27·6	22 36·0		22 45·9	0·1	0 18·3	[buried alive
1238	" 18	2 00·5	2 3·3	2 5·1	2 17·6	0·3	0 17·1	[on one island
1239	" 23	21 8·7	21 20·7		22 23·7	0·1	1 15·0	
1240	" 31	3 50·9)	4 00·7	4 19·4	9 0 ?		5 19·1	A very active
		51·2)	4 03·0					[disturbance.
			4 14·2					[Distant about
								[7,550 km.

31st Light turned down at 17·45 small disturbance missed.

Period 17·7 seconds. 1 mm. = 0″·59.

VICTORIA, B. C.

E. B. REED, SUPERINTENDENT.

No.	Date 1913	P.T. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Durat.	Remarks
		h m	h m	h m	h m	mm.	h m	
1233	Feb. 7	3 44·3	3 50·3	4 15·7	4 28·0	0·2	0 43·7	
1234	" 18	0 38·0	0 39·7	0 40·9	0 50·5	0·1	0 12·5	
1235	" 20	9 17·4			9 20·0? 9 22·7	0·1	0 5·3	
1236	" 23	3 25·5?	3 31·7	3 34·0	3 43·6	0·5	0 18·1	P. Ts. may not have
1237	Mar. 3	3 5·8	3 7·6	3 8·2	3 21·5	0·8	0 15·7	been recorded.
1238	" 4	11 49·5		11 55·7	11 59·2	0·1	0 09·7	
1239	" 6	12 1·7			12 10·7	0·05	0 9·0	
1240	" 8	16 3·5	16 15·4 16 17·4	16 18·4	17 13·6	1·3	1 10·1	Guatemala Eq.
1241	" 10	14 42 0?			14 47·0	0·05	0 5·0	
1242	" 14	8 58·6	9 9·1	9 14·0) 9 55·1)	12 8·6	4·2 4·0	3 10·0	Eq. Celebes. On one island 107 persons buried alive.
1243	" 15	14 35·2			14 39·0	0·05	0 3·8	
1244	" 15	No P.T.s	22 29·4	22 31·1	22 36·2	0·1	0 06·8	(instrument.
1245	" 18	1 48·6	1 49·3	1 49·8	2 3·4	0·2	0 14·8	(for six mins., attg.
1246	" 23	21 0·1	21 8·4	21 9·4?	22 14·6	0·3	1 14·5	Light turned off 21.29
1247	" 31	3 43·1	3 53·6 4 0·4	4 6·0 4 13·6	8 38·7	2·9 2·6	4 55·6	An active dist. contin. (for a long time. Esti- (mated dis. 7,900 km.
1248	" 31	17 21·6			17 23·3	0·05	0 1·7	Minute thickening.

Period 1·18 seconds. 1 mm. = 0″·54

J. Y.

MAGNETIC OBSERVATIONS

During February and March, 1913, the magnetic curves were normal on 31 days.

The only disturbance of note in February occurred on the 13th and 14th, and appeared in Declination as a succession of waves with a period of about 2½ hours and with an amplitude of from 20 to 25 minutes, whilst in Horizontal Force it was more active with rapid vibrations of small amplitude.

In March a series of disturbances continued almost uninterruptedly from the 13th to the 23rd and in both Horizontal Force and Declination the commencement was sudden. In Horizontal Force it began at $23^h\ 26^m$ of the 13th with a sudden increase of force equal to 27 γ and in Declination it began at $1^h\ 0^m$ of the 14th with a rapid increase of westerly declination of 15 minutes. During the whole time of disturbance the short period of the waves was quite marked both in Horizontal Force and Declination.

The following table gives an abstract of the results of magnetic observations at Agincourt for February and March.

Declination

Month	Mean of Month	Max.	Date	Min.	Date	Monthly Range	Amplitudes—Mean Daily	
							From hourly readings	From Means of Extremes
1913	° ′	° ′		° ′		° ′	′	′
Feb.	6 16·4	6 27·0	12	5 53·0	14	0 34·0	5·4	9·6
Mar.	6 17·1	6 32·6	14	6 00·1	16	0 32·5	8·9	12·9

Horizontal Force—C.G.S. Units

1913								
Feb.	0·16150	0·16181	25	0·16108	14	0·00073	0·00020	0·00033
Mar.	0·16148	0·16181	13	0·16077	14	0·00104	0·00024	0·00041

Inclination

Month	Mean Earth Inductor
1913	° ′
February	74 40·5
March	74 40·7

ASTRONOMICAL NOTES

ECLIPSE OF A STAR BY ONE OF JUPITER'S MOONS.—On the night of August 13, 1911, the third Satellite of Jupiter, Ganymede, passed directly in front of a star of the seventh magnitude, in the constellation Virgo, and for observers in the southern part of the earth, actually hid the star for more than four minutes.

Why it was important to have observations made at as many places as possible appears from the fact that, since Ganymede is much smaller than the earth, its shadow, if we may so describe the region from which at any moment it conceals the star, is only a little more than 4,000 miles in diameter.

As Jupiter and its satellite moved, this "shadow" crossed the earth, its centre passing over the southern extremity of South America, a little north of the straits of Magellan while its northern limit reached barely to the boundary between Chile and Peru. Observers at southern stations would, therefore, see the satellite pass almost centrally over the star, while for those in northern Chile the latter would be concealed for a much shorter time behind the northern edge of Ganymede.

Working along these lines, Dr. Ristenpart finds that, in order to get a satisfactory agreement between theory and observation, it is necessary to assume that the satellite, like Jupiter itself, is flattened at the poles, for otherwise the calculated length of the occultation at the northernmost station, where the star appeared to pass just inside the satellite's disc, would be much longer than the observed time. As the rate of motion of the satellite is

accurately known, the maximum length of the occultation affords a very precise measure of its diameter. Dr. Ristenpart finally concludes that the equatorial diameter of the satellite is 4,700 miles and the polar diameter 4,300. so that it is a little more flattened, in proportion to its size, than Jupiter himself. The diameter of the satellite was previously supposed, from micrometer measures, to be about 3,600 miles, and the difference between this and the new value is surprisingly large; but owing to the method of observation, Dr. Ristenpart's results seem to be entitled to very serious consideration. The mass of this satellite is known, from its attraction on the other satellites, to be about 1/12,000 that of Jupiter, or a little more than ¼ that of Mars. But, according to the results just given, it is a little larger than Mars. This would make its density less than ¼ that of Mars and actually less than that of water — intermediate between the densities of Jupiter and Saturn. Even with this low density, it must be in rapid rotation, with a period not more than ten or twelve hours, to account for the polar flattening.

It is, perhaps, most interesting of all to note that, according to the most definite of the observations, the disappearance of the star behind the satellite was almost instantaneous, the loss of light lasting only a second or so. This means that the apparent diameter of the star was not more than 1/300 that of the satellite; in other words, less than 1/500 of second of arc. This is quite what is to be expected for a star of the seventh magnitude; but it is interesting to have the extreme smallness of the apparent diameter of a star confirmed by direct observation.— *Scientific American*, March 1, 1913.

New Observatory at Los Angeles.— From clippings sent us from the Los Angeles newspapers we learn that that city is to have a splendid new educational observatory, to be erected on Mt. Hollywood, the highest point in Griffith Park. Colonel Griffith J Griffith, who gave to the city Griffith Park, has formally offered to the city $100,000 for this purpose. The observatory is to be fully equipped on or before the year 1915.

"In brief the plan is this: Mr. Griffith will erect a building of concrete, on the summit of Mt. Hollywood, which has an elevation of 1700 feet. The main building will be two stories in height. Various halls, rest rooms, recreation rooms and a moving picture theatre will be provided. A portion of the building will be three stories, the third story to be used as the observatory. It will be equipped with a number of nautical telescopes for use by the public in surveying the surrounding park country, the city, the beach towns, ships at sea, the island — whatever there may be of interest within the line of vision, — and also with telescopes for the popular study of the stars and planets. The observatory portion of the building will be so constructed that, if later it is deemed advisable, an additional structure may be erected above it for scientific astronomical studies. The observatory will be equipped under the direction of Professor Edgar L. Larkin, Director of the Lowe Observatory."

Colonel Griffith is quoted as saying: "If the cost of the project goes beyond $100,000 which I have pledged, I will pay the bills just the same. I want this institution on the summit of the peak to be educative. I want the masses to be attracted there and to be given something that will entertain them and at the same time make them think, — something that will lift them above their troubles and turn them to higher things." — *Popular Astronomy*, February, 1913.

The Explosion of Worlds. — Some interesting speculations as to the possibility of such a world as the earth being shattered by the explosive energy of the now pent-up internal forces are published by Mr. Hudson Maxim in the February number of *The Fortnightly Review*. Among other things, he shows that the pressure of the earth's crust is so great that the most powerful explosive known, in any quantity, would fail to do more than shake it locally. Gravitational pressure is so enormous that were two solid steel balls, as large as the earth and as hard as the Harveyised surface of armour-plate, gently placed in contact they would flow together like water, and could have no variation from a true sphere greater than fifty miles high. By

such arguments Mr. Maxim demonstrates the enormous strength and rigidity of the terrestrial sphere, and shows that it is immune from the effects of any shattering force less than the collision of the solar system with another celestial system.— *Nature*, March 20, 1913.

Distribution of the Spectroscopic Binary Stars.— It has been shown that seventy-four of the ninety-three known Algol-type variable stars are found within 30° of the plane of the Milky Way. This condensation toward the Milky Way is more than twice as great as that shown by the stars to the ninth magnitude taken as a whole. The Algol variables are all supposed to be spectroscopic binaries, though at present only the brighter ones have been observed for radial velocity. M. P. Stroobant has now investigated the distribution of the 306 spectroscopic binary stars included in Campbell's Second Catalogue, to determine whether a similar tendency is shown by them. His results are printed in the *Comptes Rendus*, Paris Academy, and may be summarized briefly as follows:

Two hundred and seventeen of these stars lie within 30° of the central plane of the Milky Way, but 108 of them are Class B stars. Since the known spectroscopic binaries are, with few exceptions, visible to the naked eye, we must compare this distribution with that of the naked-eye stars. Taking the latter from Houzeau, Stroobant finds that 2,565 of the 5,719 lie within galactic latitude limits ± 30°. Stated as percentages, about 40 per cent of all naked-eye stars, about 71 per cent of all known spectroscopic binary stars, and about 55 per cent of all the latter when the Class B stars are excluded, lie within 30° of the plane of the Milky Way. The observed condensation of the spectroscopic binaries toward this plane is therefore largely, but not wholly, due to the preponderance of the Class B binaries.— R. G. Aitken, *Publications Astronomical Society of the Pacific*, No. 147.

Cosmic Cloud of Calcium.—In *A. N.* 4633 Mr. Zaccheus Daniel, of the Allegheny Observatory, calls attention to the spectroscopic binary BD.— 1°943, as one in which the K-line does not share in the oscillations of the other lines. The star is

less than a degree from the spectroscopic binary δ Orionis, for which Hartmann in 1904 found the K-line to be stationary. Thirteen spectrograms have been obtained of this star with the Mellon spectrograph at Allegheny, and the measures of the best hydrogen and helium lines indicate a range in velocity of considerably more than 200 kilometres, with a period of about 3·05 days. The mean of the measures of the K-line is + 17 km. which is close to the velocity obtained by Hartmann for δ Orionis from the K-line, and so goes to confirm the supposition that this particular line is produced by absorption, not in the atmosphere of these stars, but in a calcium cloud lying between them and the solar system.— *Popular Astronomy*, No. 4.

Solar and Stellar Photospheres.—Abbot makes a much more serious effort to show that many of the observed solar phenomena may be consistent with a wholly gaseous sun. Regarding the sun as a mass of gases and vapours in which the density and temperature rapidly fall from within outwards, he utilizes the work of Rayleigh and Schuster on the scattering of light by gaseous molecules to explain the apparent boundary. He concludes that at the centre of the sun's disc light from depths greater than a few thousand miles would be completely scattered, while at the limb, on account of oblique vision, a shell of gas only a few hundred miles in thickness would suffice to veil all that lies below. There would consequently be no notable indistinctness of outline at the sun's edge. The granulation is attributed to differences of temperature, sun-spots are imagined to be vortices similar in form to waterspouts, and explanations of many other phenomena are suggested. The continuous background of the solar spectrum is accounted for, in accordance with experiment, by the pressure to which the emitting gas is subjected, and to the great effective thickness, while the dark lines are produced by the absorption of the surrounding vapours.

It will be gathered that we have still a good deal to learn as to the nature of solar and stellar photospheres, or of the equivalent radiating regions. Most observers of solar phenomena will doubtless continue to regard the photesphere as an actual cloud-like surface, and further progress in our knowledge of its constitution would seem to depend upon advances in physics.— A. Fowler, in *The Observatory*, No. 460. J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to secure Answers to Queries.

Query

Have astronomers arrived at any satisfactory knowledge of the rate and direction of the proper motion of the sun? My reason for asking the question is connected with the measurement of the distances of the stars. I understand that the base line used for this purpose is the diameter of the earth's orbit. Now if the rate of the sun's motion is known, why can they not, by waiting for years, have a base line multiplied many times in length and thus have a means of measuring all the principal stars?—J. J. E.

Answer

The rate and direction of the motion of the solar system in space are known with considerable accuracy. Campbell's results are as follows;—

Velocity, 17·8 kilometers or 11·1 miles per second,
Apex of Sun's Way, R. A. 272°, Decl + 27°·5.

The apparent displacement which a star undergoes as it is viewed from different points of the earth's orbit is due to several causes,—precession, nutation, annual aberration, proper motion and parallax. In order to obtain the last quantity we must allow for all the others and then what is left is the parallax.

Now the proper motion of a star, as ordinarily considered, is due to two causes, first, the motion it would have if we could remain at rest in space; and secondly, the motion it appears to have on account of our motion as a system through space. We cannot disentangle these two effects and we do not need to when using the method of annual parallax.

But if we wish to apply to any star the method suggested (*i.e.*

by considering our change of position after the elapse of several years) we would have to eliminate the motion due to every other cause, and this we cannot do without knowing the star's true proper motion.

Kapteyn has attempted to apply the method to a certain class of stars such as those of a particular magnitude. Taken together, the proper motions resolved in any direction will cancel, and by a statistical method he obtains the average parallax for the stars of the class. (See Moulton's *Introduction to Astronomy*, Art, 393).

HALLEY'S COMET AS SEEN IN TROPICAL AFRICA

Mr. A. W. Banfield, a missionary of Shonga, W. Africa, in a letter to the present writer describing his observations of the meteoric display of February 9, made an interesting reference to Halley's Comet as seen in tropical Africa. He says: "I have often wished that some of our astronomers had the privilege of watching Halley's Comet under the conditions in which I saw it. It came during the dry season when there are no clouds, and from April 27th until the first week in June we watched this "fiery sword," with the naked eye. On May 17 it was seen at its best; and just before daybreak I saw the head of the comet just above the horizon, while the tail passed over the zenith of the heavens. A most wonderful, majestic, terrifying sight."

AN EXCELLENT GUIDE TO THE STARS

One of the very best introductions to the practical observation of the heavenly bodies which the writer has come across is "A Beginner's Star-Book," by Kelvin McKready. It is published by Putnams, in New York, and the price is $2.75. After a pleasing introduction entitled, "Our Heritage in the Stars," the author discusses the various objects in the sky and the best method of observing them. Full and explicit instructions are given how to use modest astronomical instruments, and numer-

ous star-maps, tables giving the positions of the planets, information regarding the stars and a brief observer's catalogue of telescopic objects are also included.

But, perhaps, the most striking feature of the work is the beautiful reproductions of the finest astronomical photographs which have been taken at our great observatories. Nebulæ, comets, the planets and the moon are rendered with remarkable truth and beauty. The book certainly deserves a wide use.

PARTIAL ECLIPSE OF THE SUN, APRIL 6, 1913.

This eclipse was visible in the north-western part of Canada, and Mr. F. Napier Denison, of the Meteorological Office, Victoria, B.C., sends the following account of his observations :—

"I had the pleasure of observing the partial solar eclipse here yesterday. At the time of beginning, owing to a moderate covering of clouds, I was able within one or two minutes to observe the first contact with my 4-inch equatorial without a dark glass. I made the beginning at 8.47 a.m. 120° Standard Time ; the maximum, amounting to 0·25, occurred at 9·17 a.m. and the end at 9.52 a.m. These times you will see agree very closely with your prediction in the Royal Astronomical Society's HANDBOOK for this Province. The amount of sun covered was less than 0·424. Clear sky from time of maximum to end of eclipse.

I forward these notes thinking they may be of interest to the R. A. Society."

NEW VIEW ON THE PLEIADES

Of all star groups the Pleiades are certainly the most renowned. Long before the telescope was invented they were studied with extraordinary interest by peoples in every part of the globe. When the telescope came it revealed many more stars in the group, and then as telescopic power increased a suspicion arose that something existed in the space about these suns. On October 19, 1859, Tempel, at Venice, definitely discerned a

nebula surrounding Merope which he compared to "a stain of breath upon a mirror." Barnard and others obtained glimpses of other nebulous matter in the neighborhood, but it was only when photography came to our aid that the true state of affairs was revealed. It was then clearly seen that the various stars of the group were enveloped in nebulæ, which seemed to extend almost from one to another.

At once the idea was suggested that these great suns were being evolved from the nebulæ, that we indeed had before our eyes an example of worlds in the making. If this view were correct, of course the nebulæ must be gaseous. But the Great Nebula in Orion had been shown to be a true gas and, further, there was strong evidence that some of the stars within it were really connected with it and probably being formed by condensation from it. In addition to Orion, other nebulæ of irregular shape had been shown to be gaseous in nature, and it was confidently believed that the nebulæ in the Pleiades were gaseous too.

But a recent publication from the Lowell Observatory (*Bulletin* No. 55), prepared by Dr. V. M. Slipher, causes a halt in the procession of our ideas. The stars in the Pleiades group are of the "late Orion" type, possessing prominent hydrogen lines as well as numerous helium lines; and Dr. Slipher finds that instead of showing the bright lines of a gas, the spectrum of the nebulæ is precisely similar to that of the stars. It is a continuous spectrum with absorption lines.

Such discoveries certainly make us stop and think, and should cause us to hold our views on the evolution of the universe or the development of the stars with considerable modesty and with less finality than some of us are inclined to do.

HONOR FOR MR. PLASKETT

I learn that the University of Pittsburgh has decided to confer on Mr. J. S. Plaskett, of the Dominion Astronomical Observatory, Ottawa, the degree of D.Sc., and the readers of

the JOURNAL will agree with me that it is an honor well deserved. Fuller particulars will be given when the formal presentation is made in June.

HOPE YET FOR THE 100-INCH TELESCOPE

On the authority of *Popular Astronomy*, it was stated in our last issue that it had been definitely decided to discard the great disc of glass from which the mirror was being fashioned. This report, I find, was not correct. Mr. J. S. Plaskett has just returned from a visit to the Mt. Wilson Solar Observatory and states that a method of mounting has been devised for the mirror which supports it in such a way that there is no noticeable distortion of the glass when it is placed in any position. The glass may be used after all.

DR. THOMAS DICK: LETTER TO THE EDITOR

In Mr. Brashear's interesting article on Dr. Thomas Dick he has the following note on the signature "Monck" to the Treasury Minute allowing the pension:—"Monck was Sir Charles Stanley and Lord of the Treasury from 1855 to 1858." This should be "Monck was Charles Stanley Monck, Viscount Monck, who was then a Junior Lord of the Treasury and was afterwards better known as Governor General of Canada." I remain,

Truly yours,

W. H. STANLEY MONCK.

17 Clyde Road, Dublin,
April 14.

(Viscount Monck was Governor General from October, 1861 to November, 1868, and was thus in office when the new Dominion of Canada was inaugurated. —C. A. C.)

REPORT ON THE METEORIC DISPLAY

The writer had intended to print in this number a report on the great meteoric display of February 9, but it has been impossible to have it ready in time. It will appear in the next issue.

C. A. C.